(12) **United States Patent**
Fisher

(10) **Patent No.: US 9,478,083 B2**
(45) **Date of Patent: *Oct. 25, 2016**

(54) **ELECTRONIC KEY LOCKOUT CONTROL IN LOCKBOX SYSTEM**

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(72) Inventor: **Scott R. Fisher**, West Chester, OH (US)

(73) Assignee: **SentriLock, LLC**, Cincinnati, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/563,165**

(22) Filed: **Dec. 8, 2014**

(65) **Prior Publication Data**

US 2015/0091696 A1 Apr. 2, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/790,605, filed on Mar. 8, 2013, now Pat. No. 8,912,884, which is a continuation-in-part of application No. 12/883,628, filed on Sep. 16, 2010, now Pat. No. 8,593,252.

(51) **Int. Cl.**
G07C 9/00 (2006.01)
G05B 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G07C 9/00111*** (2013.01); ***G05B 1/00*** (2013.01); ***G07C 9/00571*** (2013.01); ***G07C 9/00896*** (2013.01); *G07C 2009/00793* (2013.01)

(58) **Field of Classification Search**
CPC E05B 19/0005; E05B 41/00; E05B 2047/0094; G07C 9/0069; G07C 9/00896; G07C 9/00023; G07C 2209/08
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,705,991	A *	1/1998	Kniffin	G07C 9/00023 340/12.5
6,822,553	B1	11/2004	Henderson	
6,989,732	B2	1/2006	Fisher	
7,880,584	B2	2/2011	Larson	
7,999,656	B2 *	8/2011	Fisher	G07C 9/00103 340/5.73
8,451,088	B2 *	5/2013	Fisher	A47G 29/10 340/5.73
2003/0179075	A1 *	9/2003	Greenman	E05B 19/0005 340/5.54
2005/0165612	A1 *	7/2005	Van Rysselberghe	A47G 29/141 705/26.1
2007/0090921	A1 *	4/2007	Fisher	G07C 9/00103 340/5.73

(Continued)

OTHER PUBLICATIONS

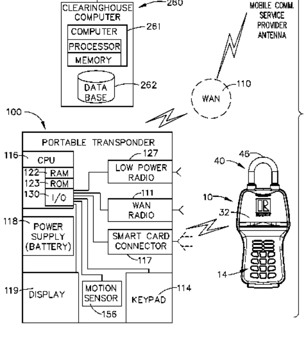
International Search Report, PCT/US2013/072656; 7 pages (Feb. 28, 2014).

Primary Examiner — Fekadeselassie Girma
(74) *Attorney, Agent, or Firm* — Frederick H. Gribbell

(57) **ABSTRACT**

An electronic lockbox system includes a wireless portable transponder that communicates with an electronic lockbox using a low power radio link. The portable transponder includes: a wide area network radio to communicate to a central clearinghouse computer, a motion sensor to activate its wide area network radio, and a connector to communicate with a secure memory device. The electronic lockbox sends a hail message that is intercepted by the portable transponder; the hail message includes identification information. The portable transponder responds with a message that includes a time sensitive encryption key; the lockbox authenticates this response message using its own time sensitive encryption key. If an electronic key is used to access the lockbox, the improved system effectively disables the electronic key during a showing, so that the electronic key cannot be used to access another lockbox until the correct dwelling key has been placed back into the lockbox.

8 Claims, 19 Drawing Sheets



(56) References Cited

U.S. PATENT DOCUMENTS

2007/0296545	A1 *	12/2007	Clare	E05B 67/00 340/5.64
2008/0246587	A1 *	10/2008	Fisher	A47G 29/10 340/5.73
2009/0153291	A1	6/2009	Larson	
2010/0283361	A1 *	11/2010	Sato	G07C 9/00896 312/222
2011/0130134	A1 *	6/2011	Van Rysselberghe	A47G 29/141 455/422.1
2013/0127594	A1 *	5/2013	Sato	A47G 29/10 340/5.73

* cited by examiner

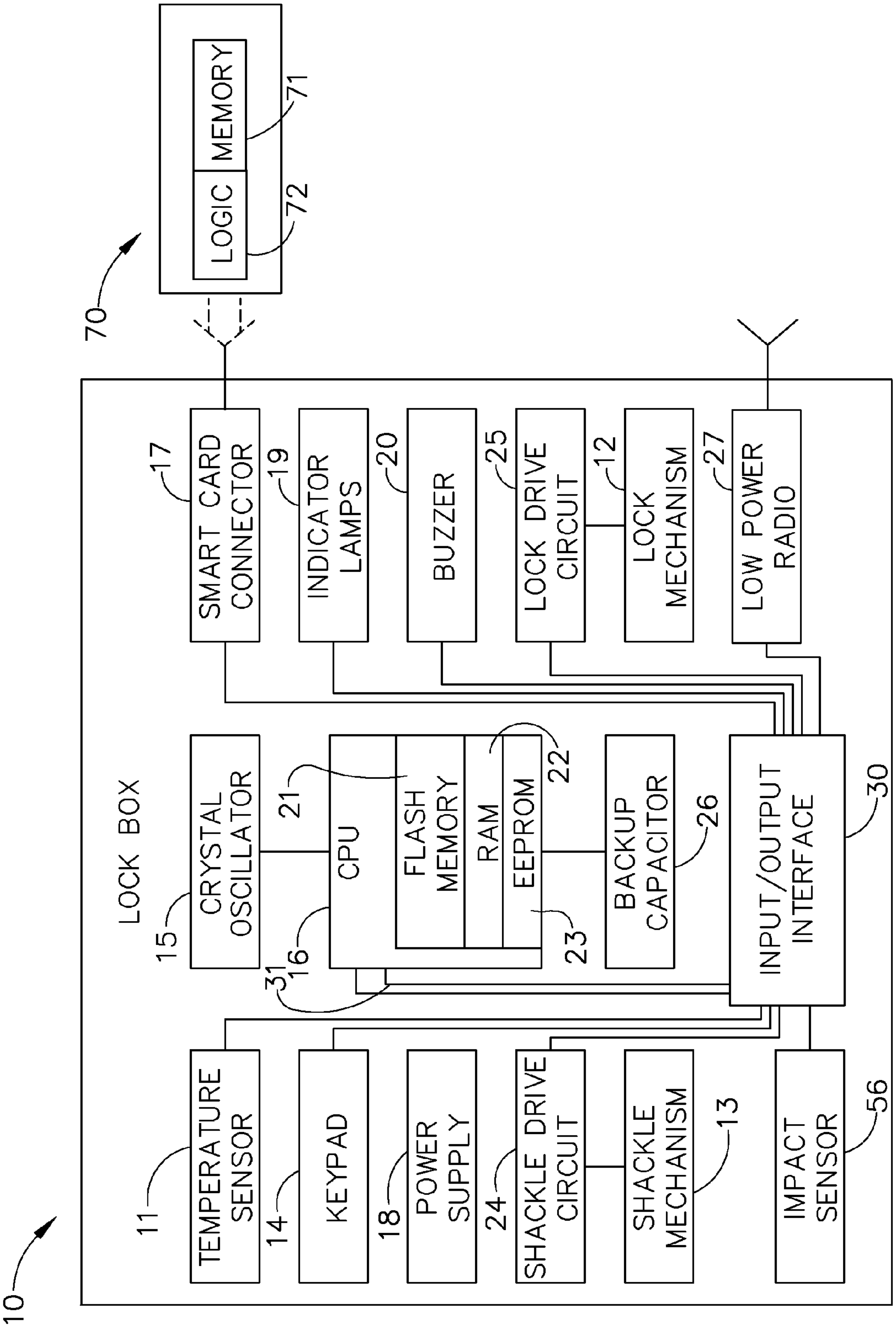

10
LOCK BOX
11
TEMPERATURE SENSOR
14
KEYPAD
18
POWER SUPPLY
24
SHACKLE DRIVE CIRCUIT
SHACKLE MECHANISM
13
IMPACT SENSOR
56
15
CRYSTAL OSCILLATOR
16
31
CPU
21
FLASH MEMORY
RAM
EEPROM
22
23
BACKUP CAPACITOR
26
INPUT/OUTPUT INTERFACE
30
17
SMART CARD CONNECTOR
19
INDICATOR LAMPS
20
BUZZER
25
LOCK DRIVE CIRCUIT
12
LOCK MECHANISM
27
LOW POWER RADIO
70
LOGIC
72
MEMORY
71

FIG. 1

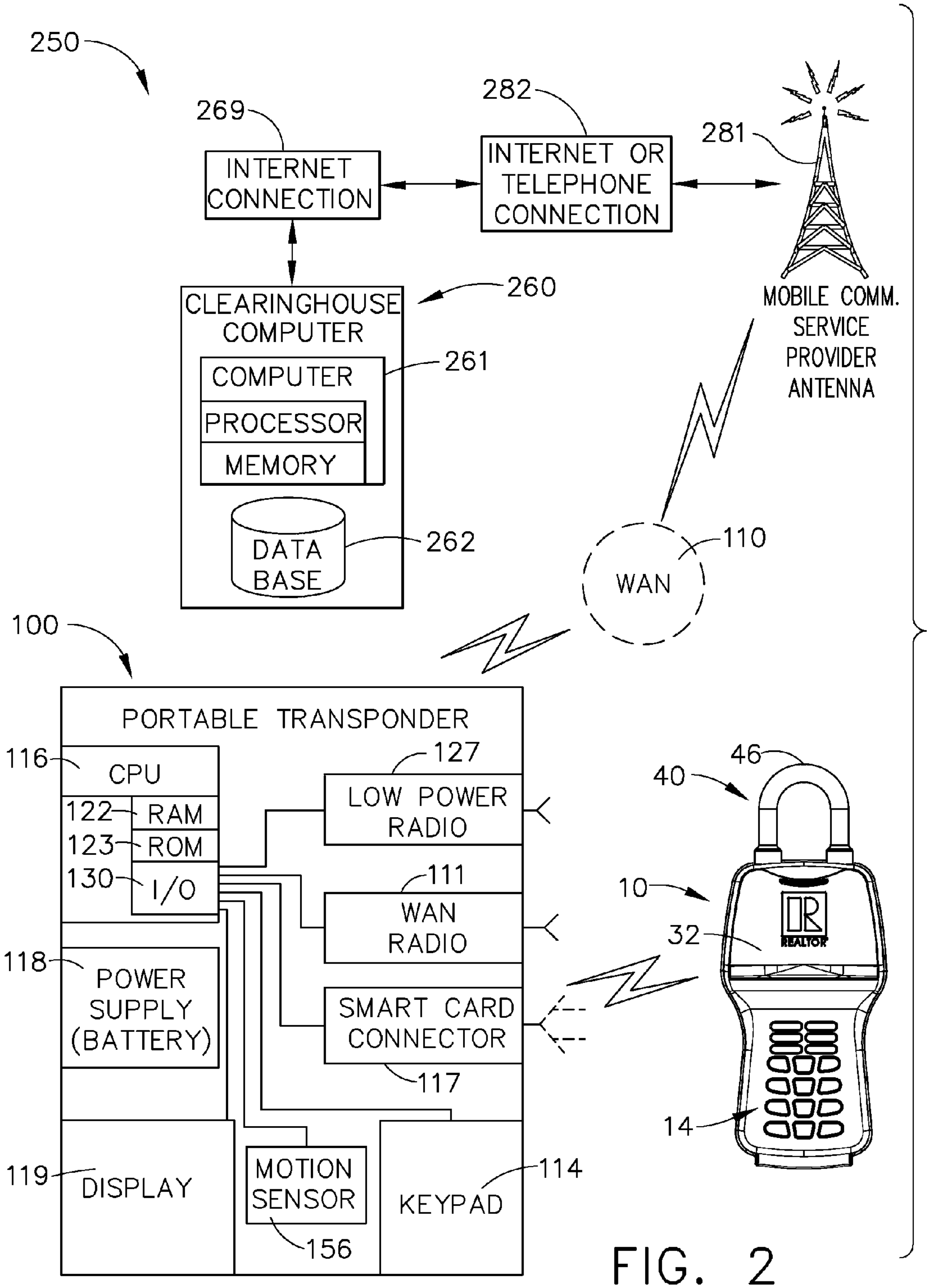

250
269
INTERNET CONNECTION
282
INTERNET OR TELEPHONE CONNECTION
281
MOBILE COMM. SERVICE PROVIDER ANTENNA
CLEARINGHOUSE COMPUTER
260
COMPUTER
261
PROCESSOR
MEMORY
DATA BASE
262
WAN
110
100
PORTABLE TRANSPONDER
116
CPU
127
LOW POWER RADIO
122
RAM
123
ROM
130
I/O
111
WAN RADIO
118
POWER SUPPLY (BATTERY)
SMART CARD CONNECTOR
117
119
DISPLAY
MOTION SENSOR
156
KEYPAD
114
46
40
10
32
REALTOR
14

FIG. 2

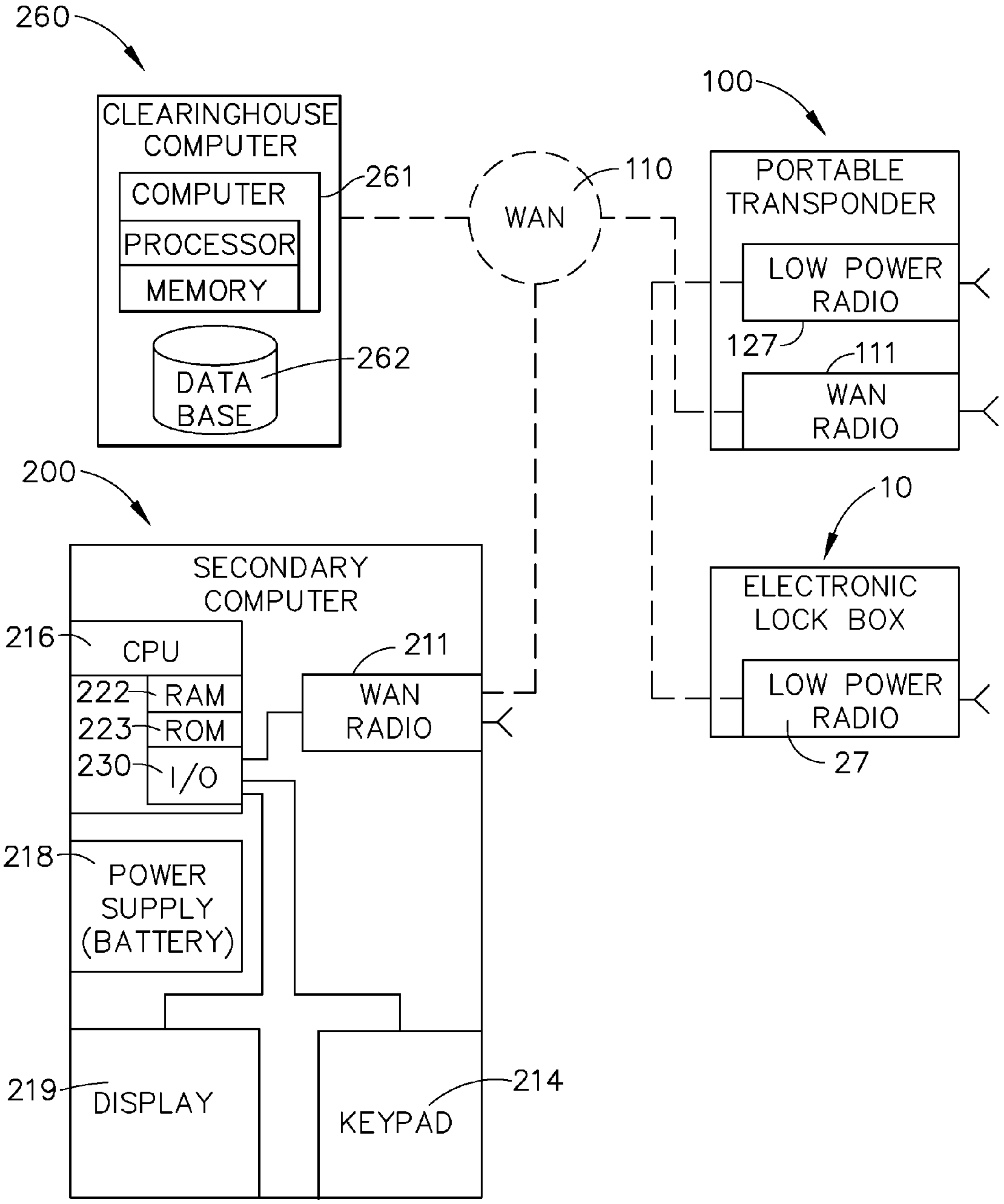

260
CLEARINGHOUSE COMPUTER
COMPUTER
PROCESSOR
MEMORY
261
DATA BASE
262
WAN
110
100
PORTABLE TRANSPONDER
LOW POWER RADIO
127
111
WAN RADIO
10
ELECTRONIC LOCK BOX
LOW POWER RADIO
27
200
SECONDARY COMPUTER
216
CPU
222
RAM
223
ROM
230
I/O
211
WAN RADIO
218
POWER SUPPLY (BATTERY)
219
DISPLAY
214
KEYPAD

FIG. 3

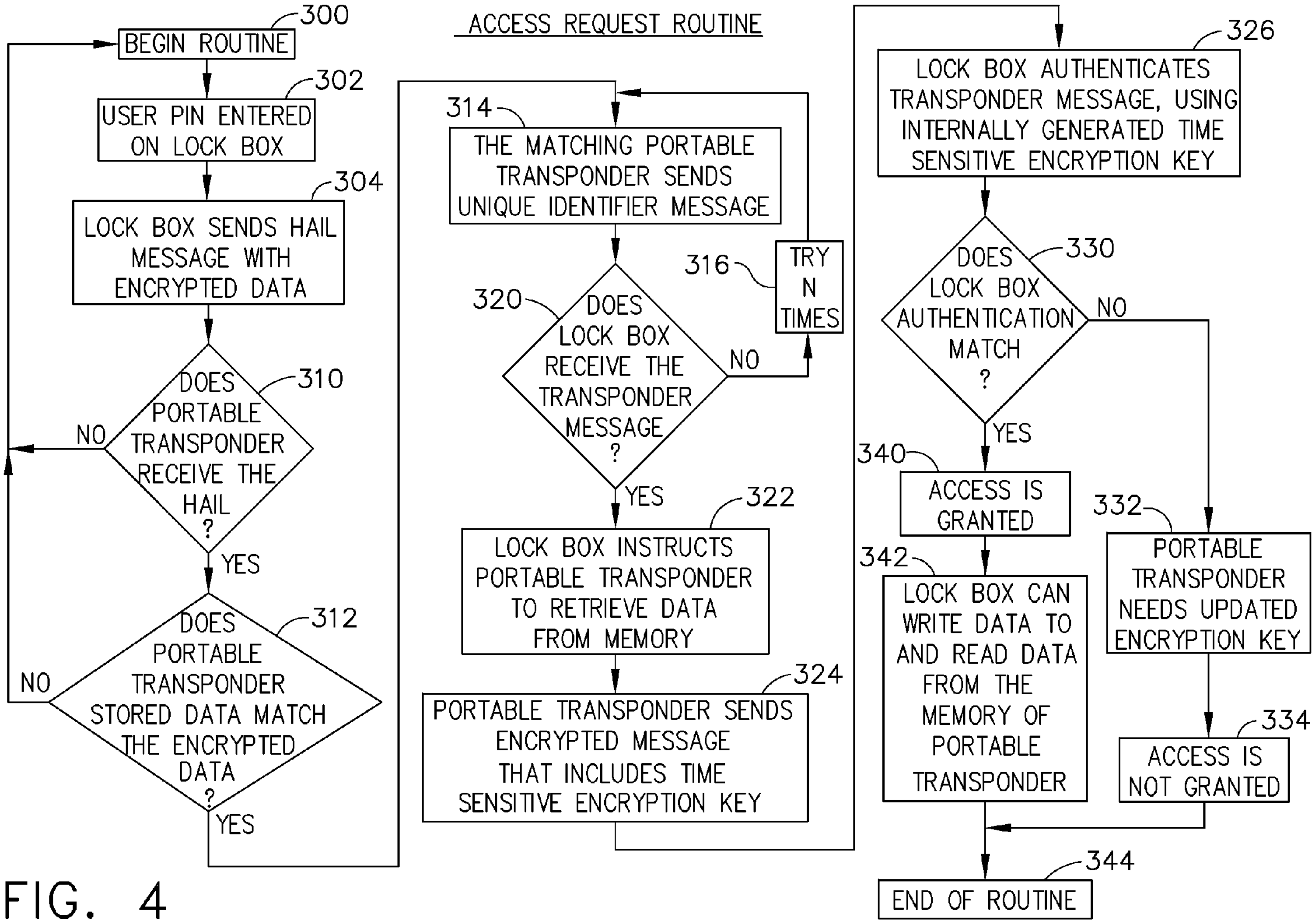

ACCESS REQUEST ROUTINE
300
BEGIN ROUTINE
302
USER PIN ENTERED ON LOCK BOX
304
LOCK BOX SENDS HAIL MESSAGE WITH ENCRYPTED DATA
310
DOES PORTABLE TRANSPONDER RECEIVE THE HAIL ?
NO
YES
312
DOES PORTABLE TRANSPONDER STORED DATA MATCH THE ENCRYPTED DATA ?
NO
YES
314
THE MATCHING PORTABLE TRANSPONDER SENDS UNIQUE IDENTIFIER MESSAGE
320
DOES LOCK BOX RECEIVE THE TRANSPONDER MESSAGE ?
NO
316
TRY N TIMES
YES
322
LOCK BOX INSTRUCTS PORTABLE TRANSPONDER TO RETRIEVE DATA FROM MEMORY
324
PORTABLE TRANSPONDER SENDS ENCRYPTED MESSAGE THAT INCLUDES TIME SENSITIVE ENCRYPTION KEY
326
LOCK BOX AUTHENTICATES TRANSPONDER MESSAGE, USING INTERNALLY GENERATED TIME SENSITIVE ENCRYPTION KEY
330
DOES LOCK BOX AUTHENTICATION MATCH ?
NO
YES
340
ACCESS IS GRANTED
342
LOCK BOX CAN WRITE DATA TO AND READ DATA FROM THE MEMORY OF PORTABLE TRANSPONDER
332
PORTABLE TRANSPONDER NEEDS UPDATED ENCRYPTION KEY
334
ACCESS IS NOT GRANTED
344
END OF ROUTINE

FIG. 4

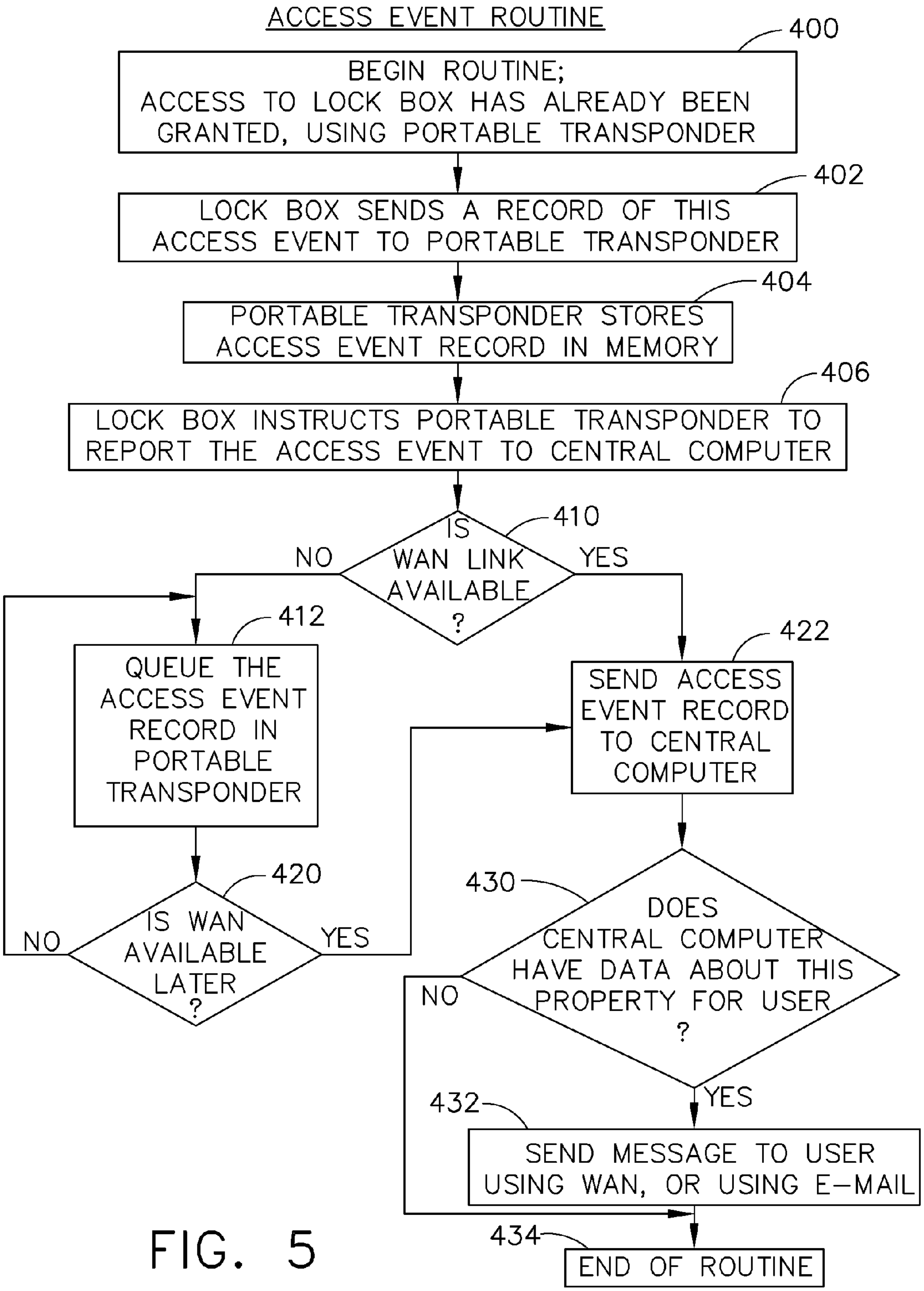

ACCESS EVENT ROUTINE
400
BEGIN ROUTINE; ACCESS TO LOCK BOX HAS ALREADY BEEN GRANTED, USING PORTABLE TRANSPONDER
402
LOCK BOX SENDS A RECORD OF THIS ACCESS EVENT TO PORTABLE TRANSPONDER
404
PORTABLE TRANSPONDER STORES ACCESS EVENT RECORD IN MEMORY
406
LOCK BOX INSTRUCTS PORTABLE TRANSPONDER TO REPORT THE ACCESS EVENT TO CENTRAL COMPUTER
410
IS WAN LINK AVAILABLE ?
NO
YES
412
QUEUE THE ACCESS EVENT RECORD IN PORTABLE TRANSPONDER
422
SEND ACCESS EVENT RECORD TO CENTRAL COMPUTER
420
IS WAN AVAILABLE LATER ?
NO
YES
430
DOES CENTRAL COMPUTER HAVE DATA ABOUT THIS PROPERTY FOR USER ?
NO
YES
432
SEND MESSAGE TO USER USING WAN, OR USING E-MAIL
434
END OF ROUTINE

FIG. 5

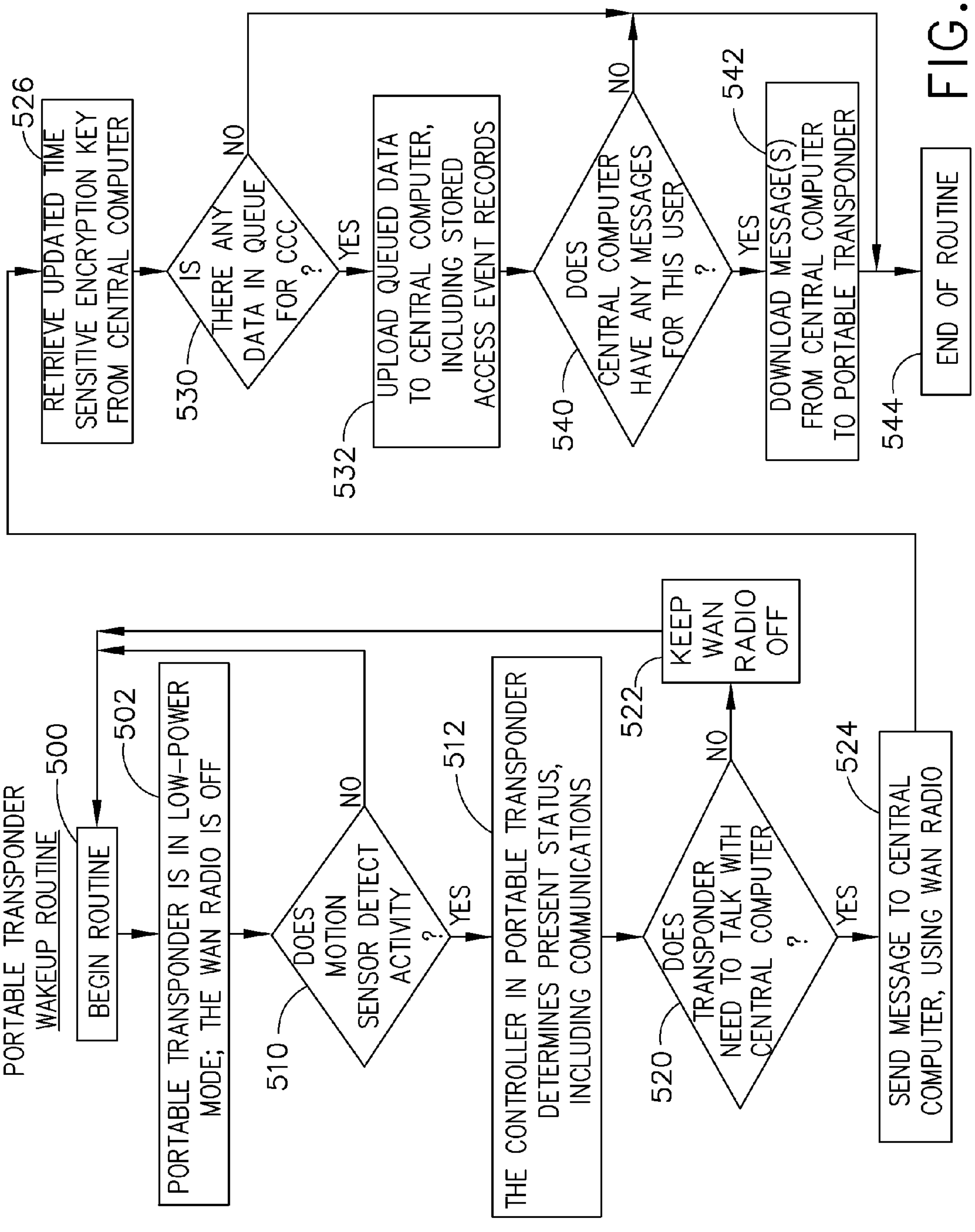

PORTABLE TRANSPONDER WAKEUP ROUTINE
500
BEGIN ROUTINE
502
PORTABLE TRANSPONDER IS IN LOW-POWER MODE; THE WAN RADIO IS OFF
510
DOES MOTION SENSOR DETECT ACTIVITY ?
NO
YES
512
THE CONTROLLER IN PORTABLE TRANSPONDER DETERMINES PRESENT STATUS, INCLUDING COMMUNICATIONS
520
DOES TRANSPONDER NEED TO TALK WITH CENTRAL COMPUTER ?
NO
522
KEEP WAN RADIO OFF
YES
524
SEND MESSAGE TO CENTRAL COMPUTER, USING WAN RADIO
526
RETRIEVE UPDATED TIME SENSITIVE ENCRYPTION KEY FROM CENTRAL COMPUTER
530
IS THERE ANY DATA IN QUEUE FOR CCC ?
NO
YES
532
UPLOAD QUEUED DATA TO CENTRAL COMPUTER, INCLUDING STORED ACCESS EVENT RECORDS
540
DOES CENTRAL COMPUTER HAVE ANY MESSAGES FOR THIS USER ?
NO
YES
542
DOWNLOAD MESSAGE(S) FROM CENTRAL COMPUTER TO PORTABLE TRANSPONDER
544
END OF ROUTINE

FIG. 6

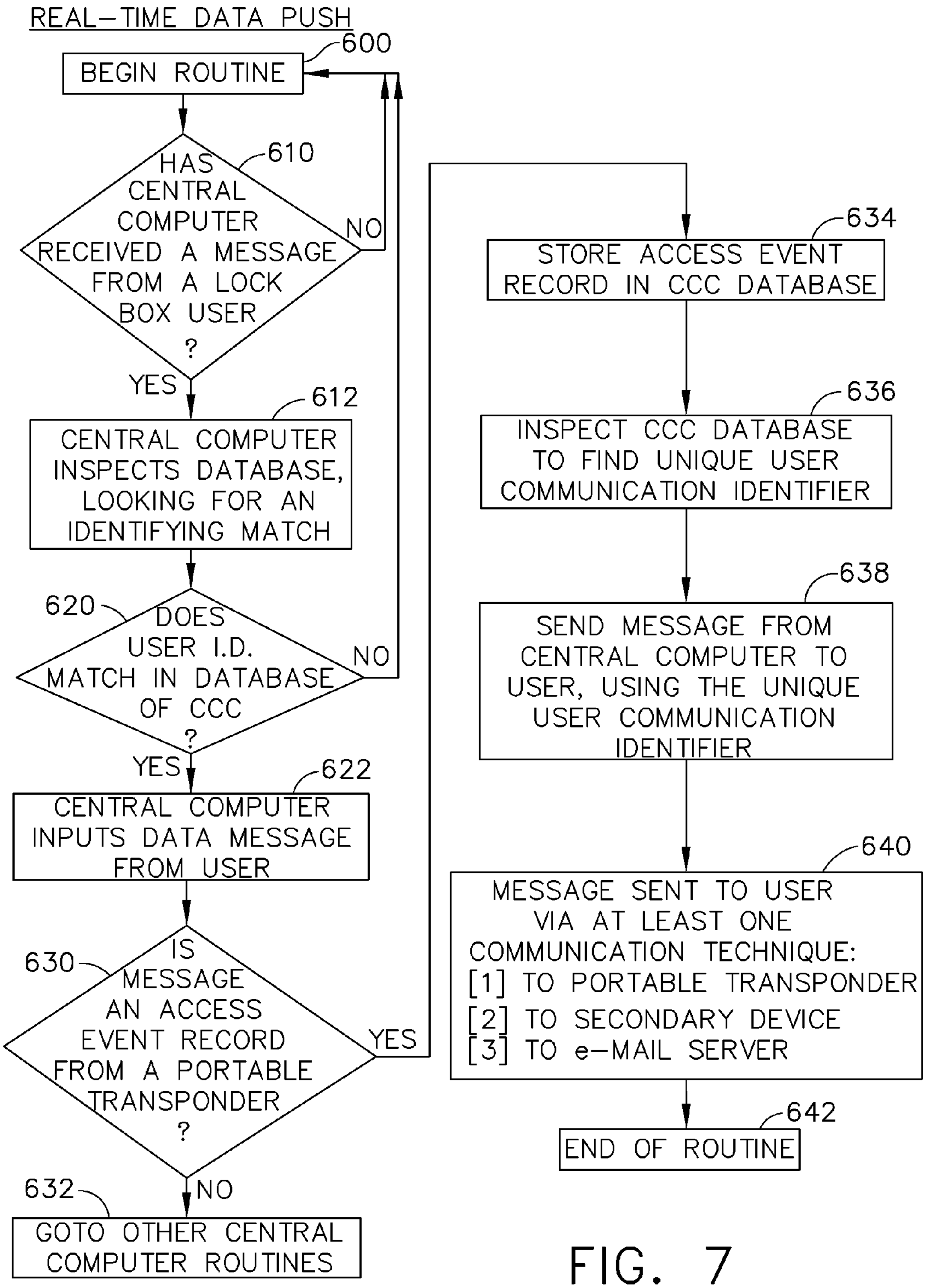

REAL-TIME DATA PUSH
600
BEGIN ROUTINE
610
HAS CENTRAL COMPUTER RECEIVED A MESSAGE FROM A LOCK BOX USER ?
NO
YES
612
CENTRAL COMPUTER INSPECTS DATABASE, LOOKING FOR AN IDENTIFYING MATCH
620
DOES USER I.D. MATCH IN DATABASE OF CCC ?
NO
YES
622
CENTRAL COMPUTER INPUTS DATA MESSAGE FROM USER
630
IS MESSAGE AN ACCESS EVENT RECORD FROM A PORTABLE TRANSPONDER ?
YES
NO
632
GOTO OTHER CENTRAL COMPUTER ROUTINES
634
STORE ACCESS EVENT RECORD IN CCC DATABASE
636
INSPECT CCC DATABASE TO FIND UNIQUE USER COMMUNICATION IDENTIFIER
638
SEND MESSAGE FROM CENTRAL COMPUTER TO USER, USING THE UNIQUE USER COMMUNICATION IDENTIFIER
640
MESSAGE SENT TO USER VIA AT LEAST ONE COMMUNICATION TECHNIQUE:
[1] TO PORTABLE TRANSPONDER
[2] TO SECONDARY DEVICE
[3] TO e-MAIL SERVER
642
END OF ROUTINE

FIG. 7

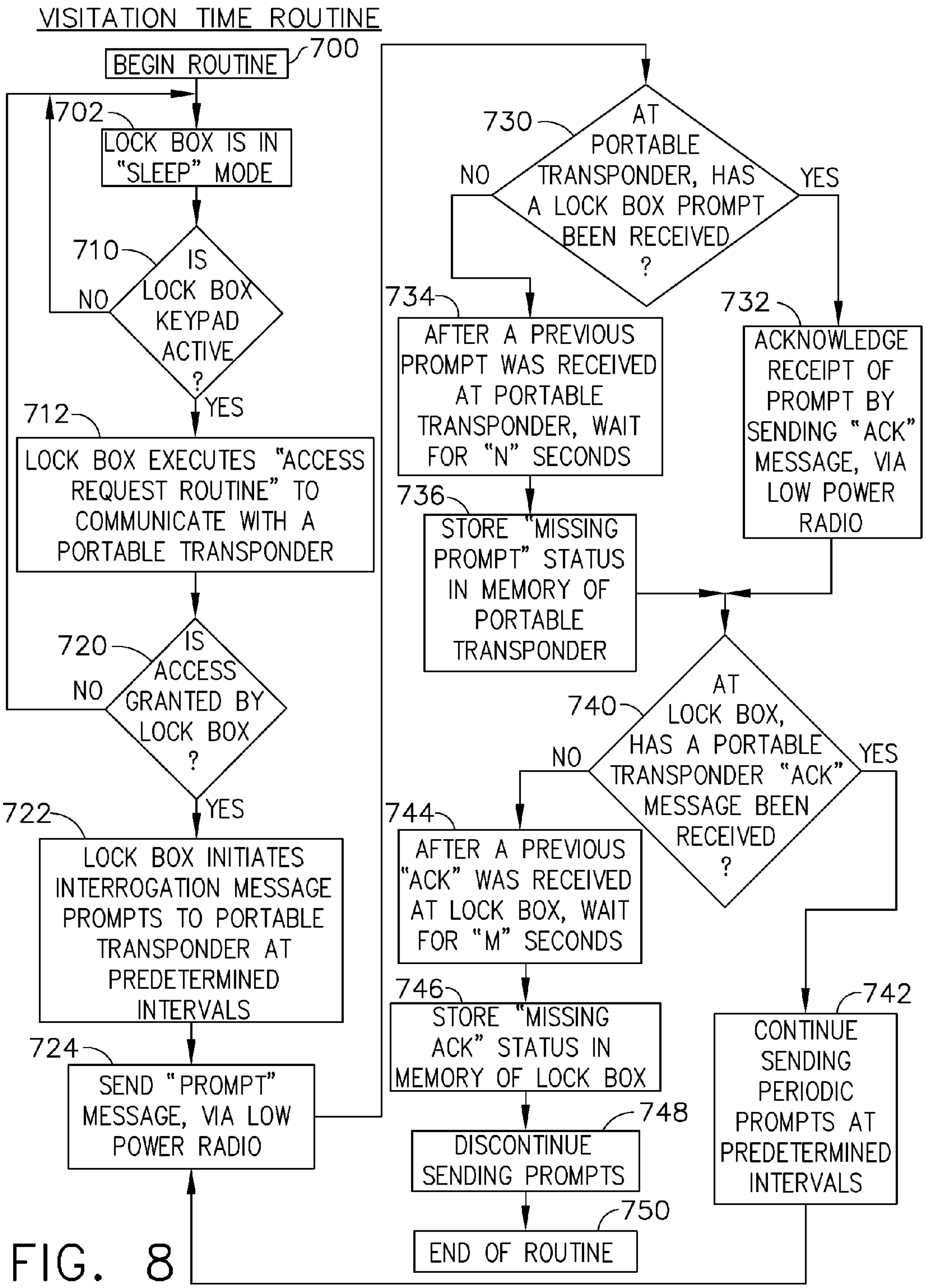
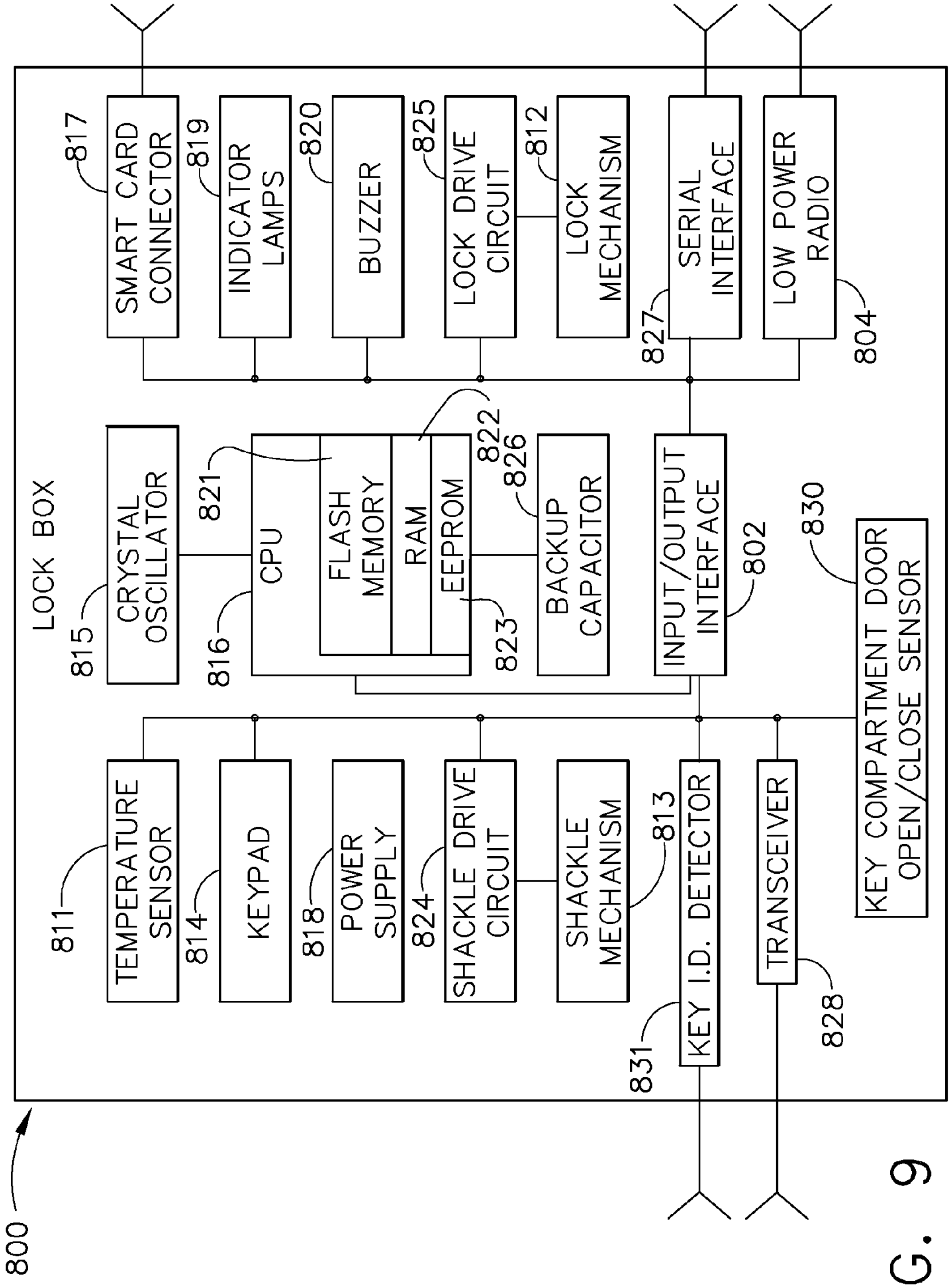
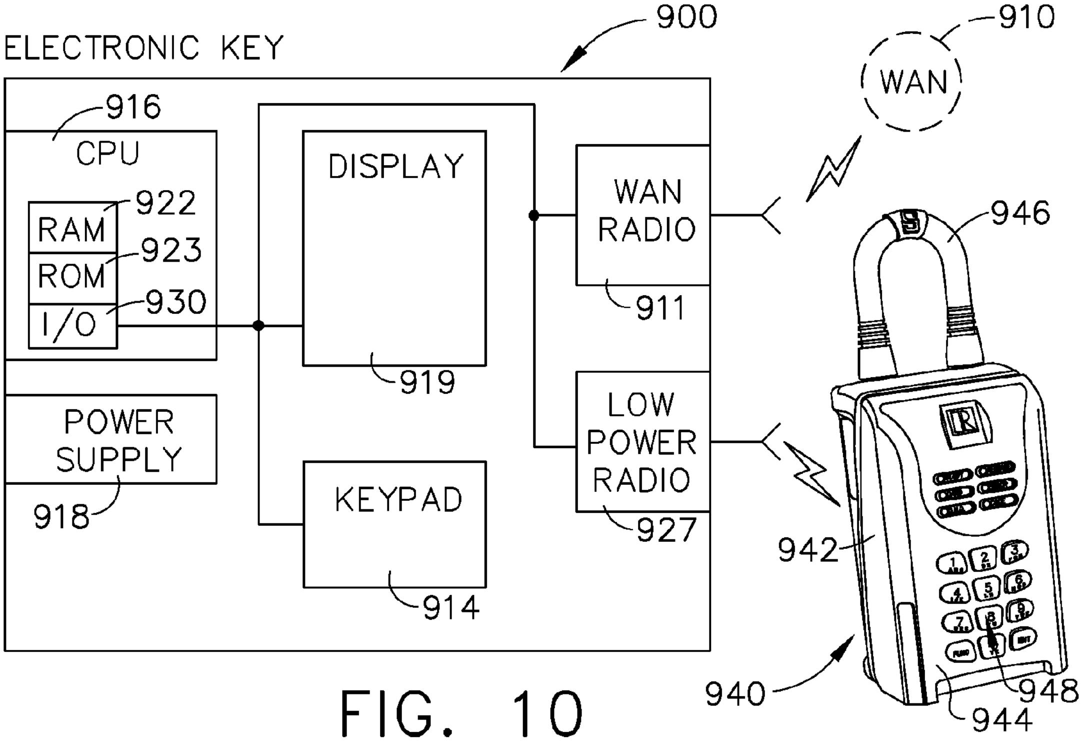

VISITATION TIME ROUTINE
BEGIN ROUTINE
700
702
LOCK BOX IS IN "SLEEP" MODE
710
IS LOCK BOX KEYPAD ACTIVE ?
NO
YES
712
LOCK BOX EXECUTES "ACCESS REQUEST ROUTINE" TO COMMUNICATE WITH A PORTABLE TRANSPONDER
720
IS ACCESS GRANTED BY LOCK BOX ?
NO
YES
722
LOCK BOX INITIATES INTERROGATION MESSAGE PROMPTS TO PORTABLE TRANSPONDER AT PREDETERMINED INTERVALS
724
SEND "PROMPT" MESSAGE, VIA LOW POWER RADIO
730
AT PORTABLE TRANSPONDER, HAS A LOCK BOX PROMPT BEEN RECEIVED ?
NO
YES
734
AFTER A PREVIOUS PROMPT WAS RECEIVED AT PORTABLE TRANSPONDER, WAIT FOR "N" SECONDS
732
ACKNOWLEDGE RECEIPT OF PROMPT BY SENDING "ACK" MESSAGE, VIA LOW POWER RADIO
736
STORE "MISSING PROMPT" STATUS IN MEMORY OF PORTABLE TRANSPONDER
740
AT LOCK BOX, HAS A PORTABLE TRANSPONDER "ACK" MESSAGE BEEN RECEIVED ?
NO
YES
744
AFTER A PREVIOUS "ACK" WAS RECEIVED AT LOCK BOX, WAIT FOR "M" SECONDS
746
STORE "MISSING ACK" STATUS IN MEMORY OF LOCK BOX
748
DISCONTINUE SENDING PROMPTS
750
END OF ROUTINE
742
CONTINUE SENDING PERIODIC PROMPTS AT PREDETERMINED INTERVALS

FIG. 8



800
LOCK BOX
817
SMART CARD CONNECTOR
819
INDICATOR LAMPS
820
BUZZER
825
LOCK DRIVE CIRCUIT
812
LOCK MECHANISM
827
SERIAL INTERFACE
804
LOW POWER RADIO
815
CRYSTAL OSCILLATOR
816
CPU
821
FLASH MEMORY
822
RAM
823
EEPROM
826
BACKUP CAPACITOR
802
INPUT/OUTPUT INTERFACE
830
KEY COMPARTMENT DOOR OPEN/CLOSE SENSOR
811
TEMPERATURE SENSOR
814
KEYPAD
818
POWER SUPPLY
824
SHACKLE DRIVE CIRCUIT
SHACKLE MECHANISM
813
831
KEY I.D. DETECTOR
828
TRANSCEIVER

FIG. 9


900
ELECTRONIC KEY
916
CPU
RAM
922
ROM
923
I/O
930
POWER
SUPPLY
918
DISPLAY
919
KEYPAD
914
WAN
RADIO
911
LOW
POWER
RADIO
927
WAN
910
946
942
940
948
944

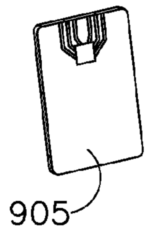

905

FIG. 10

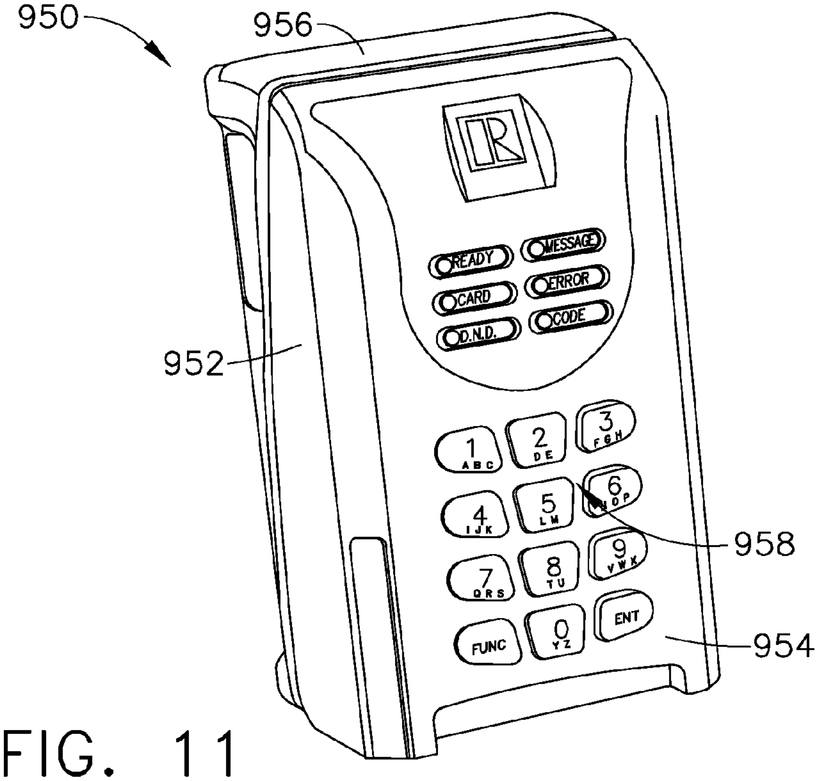

950
956
952
READY
MESSAGE
CARD
ERROR
D.N.D.
CODE
1 ABC
2 DE
3 FGH
4 IJK
5 LM
6 NOP
7 QRS
8 TU
9 VWX
FUNC
0 YZ
ENT
958
954

FIG. 11

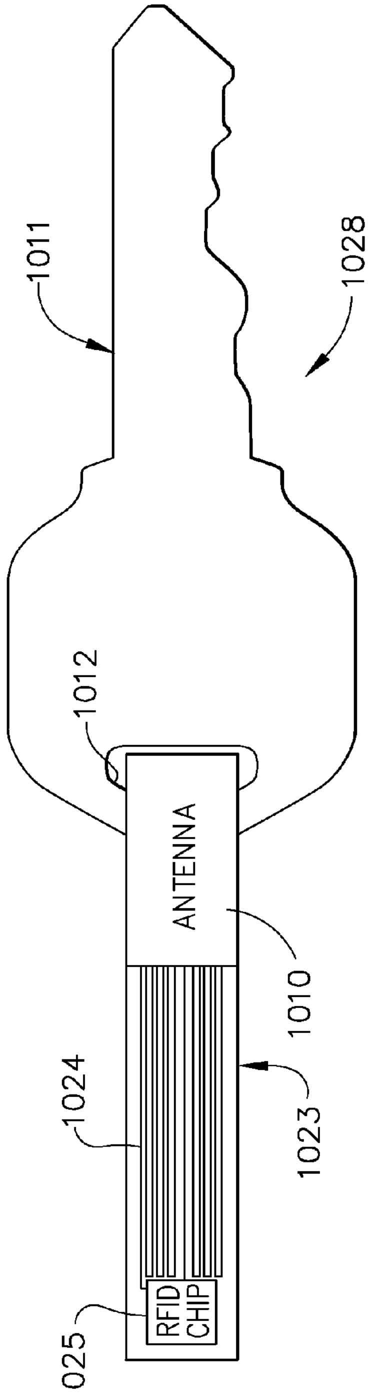

1011
1028
1012
ANTENNA
1010
1024
1023
RFID CHIP
1025

FIG. 12

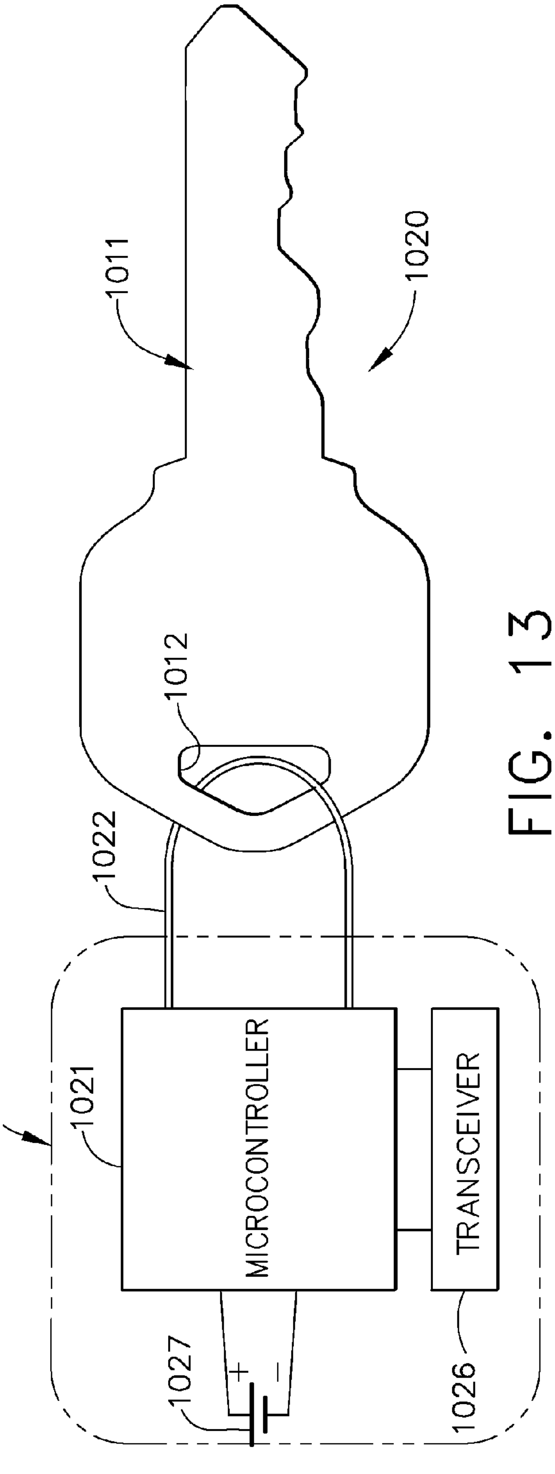

1011
1020
1012
1022
1015
1021
MICROCONTROLLER
TRANSCEIVER
1027
+
−
1026

FIG. 13

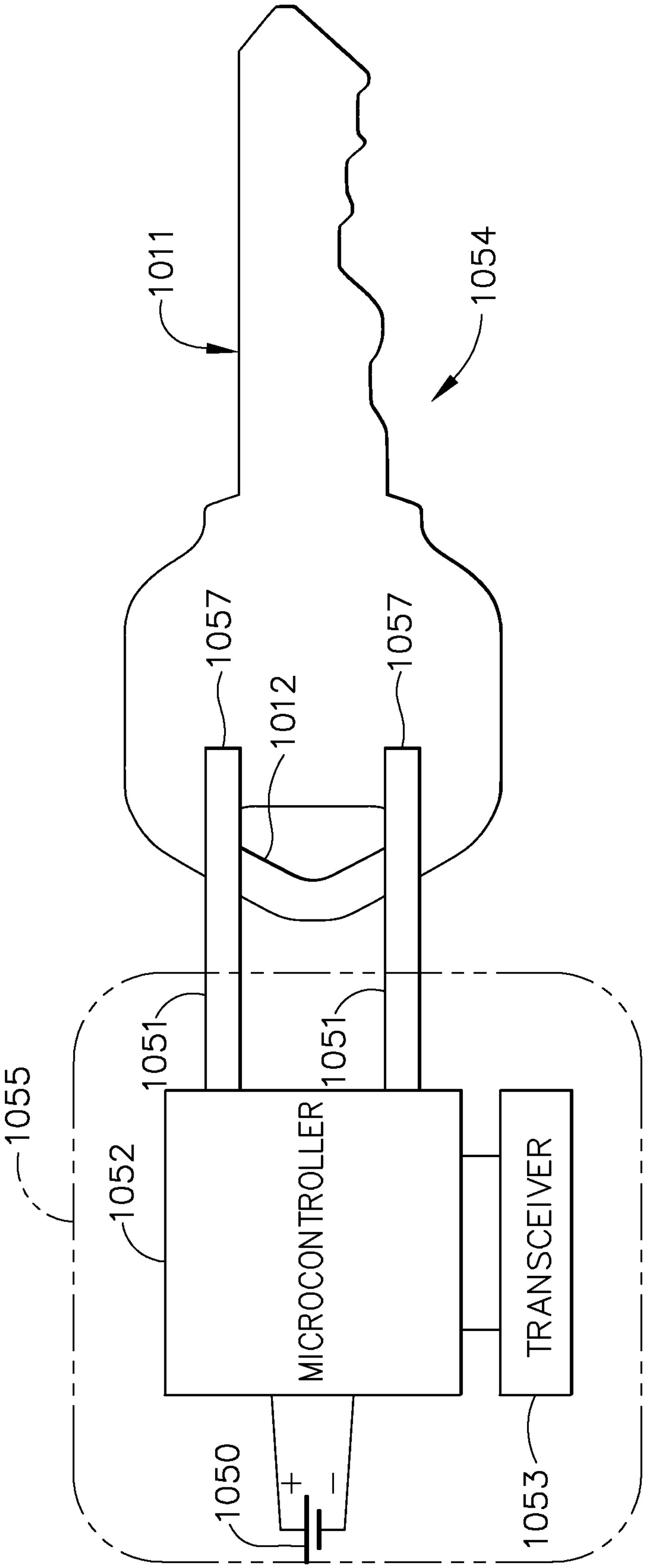

1011
1054
1057
1057
1012
1051
1051
1055
1052
MICROCONTROLLER
TRANSCEIVER
1050
+
-
1053

FIG. 14

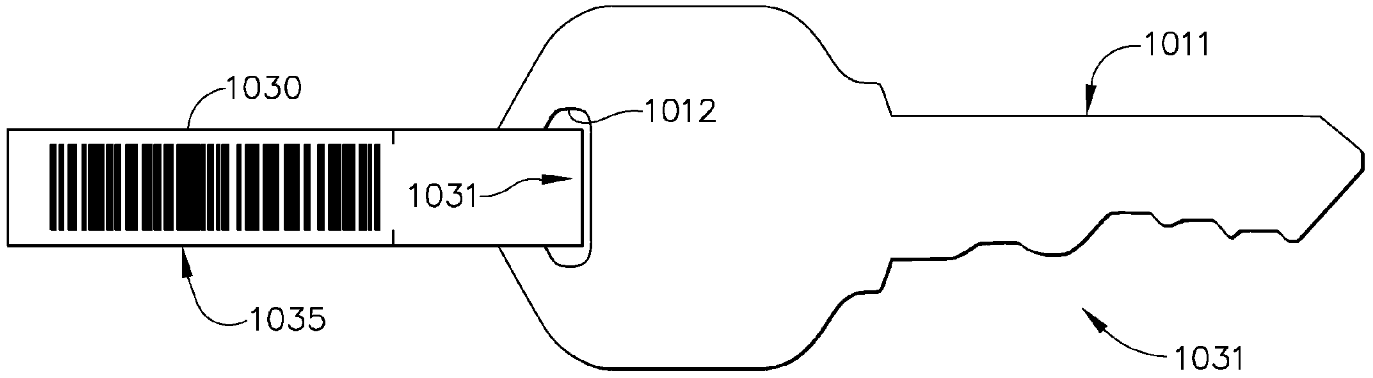


FIG. 15

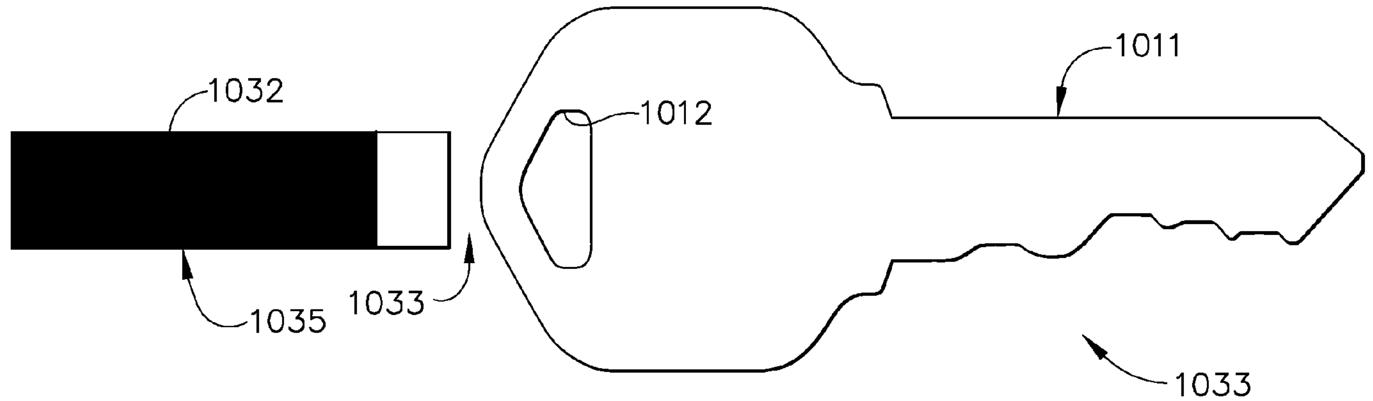


FIG. 16

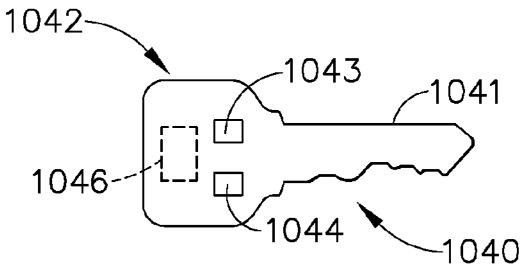


FIG. 17

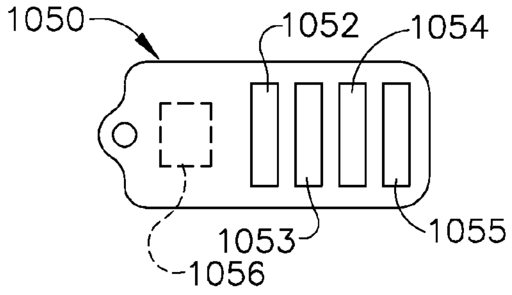


FIG. 18

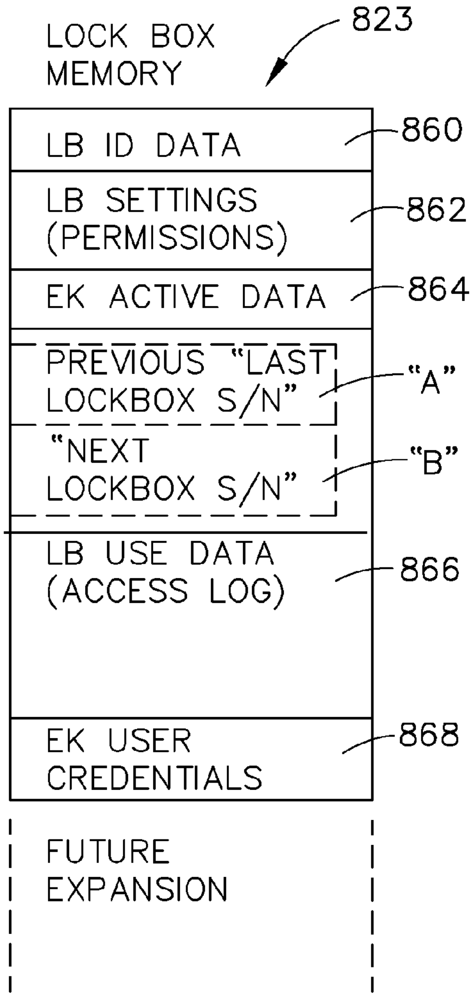


FIG. 19

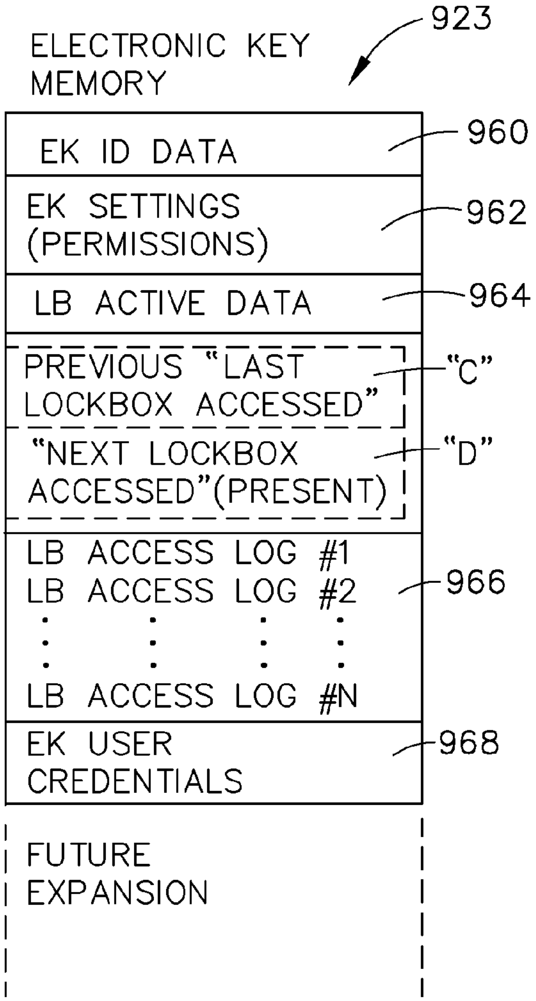


FIG. 20

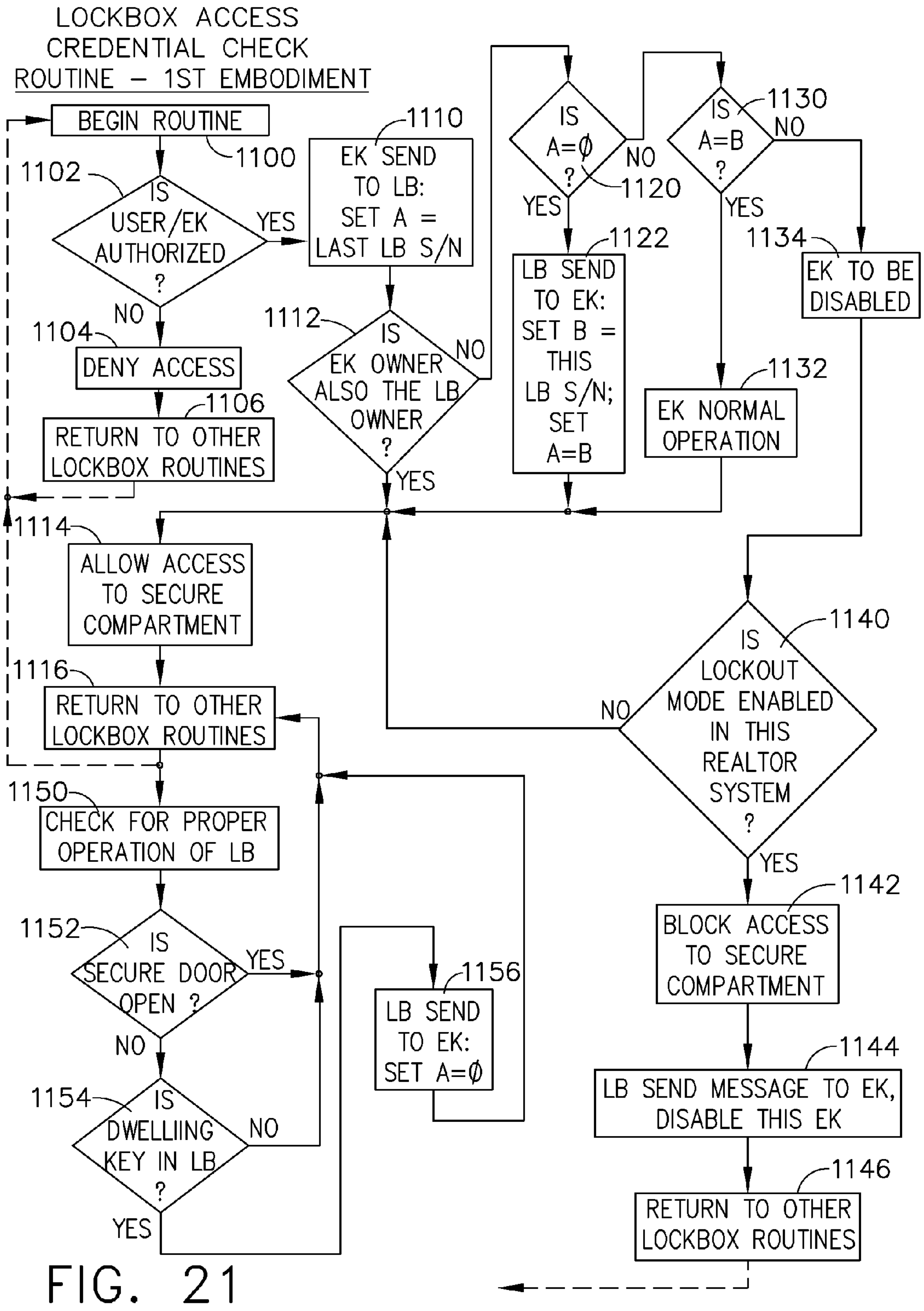

LOCKBOX ACCESS
CREDENTIAL CHECK
ROUTINE – 1ST EMBODIMENT
BEGIN ROUTINE
1100
1102
IS USER/EK AUTHORIZED ?
YES
NO
1104
DENY ACCESS
1106
RETURN TO OTHER LOCKBOX ROUTINES
1110
EK SEND TO LB: SET A = LAST LB S/N
1112
IS EK OWNER ALSO THE LB OWNER ?
NO
YES
IS A=∅ ?
NO
1120
YES
1122
LB SEND TO EK: SET B = THIS LB S/N; SET A=B
IS A=B ?
1130
NO
YES
1134
EK TO BE DISABLED
1132
EK NORMAL OPERATION
1114
ALLOW ACCESS TO SECURE COMPARTMENT
1116
RETURN TO OTHER LOCKBOX ROUTINES
1140
IS LOCKOUT MODE ENABLED IN THIS REALTOR SYSTEM ?
NO
YES
1142
BLOCK ACCESS TO SECURE COMPARTMENT
1144
LB SEND MESSAGE TO EK, DISABLE THIS EK
1146
RETURN TO OTHER LOCKBOX ROUTINES
1150
CHECK FOR PROPER OPERATION OF LB
1152
IS SECURE DOOR OPEN ?
YES
NO
1154
IS DWELLIING KEY IN LB ?
NO
YES
1156
LB SEND TO EK: SET A=∅

FIG. 21

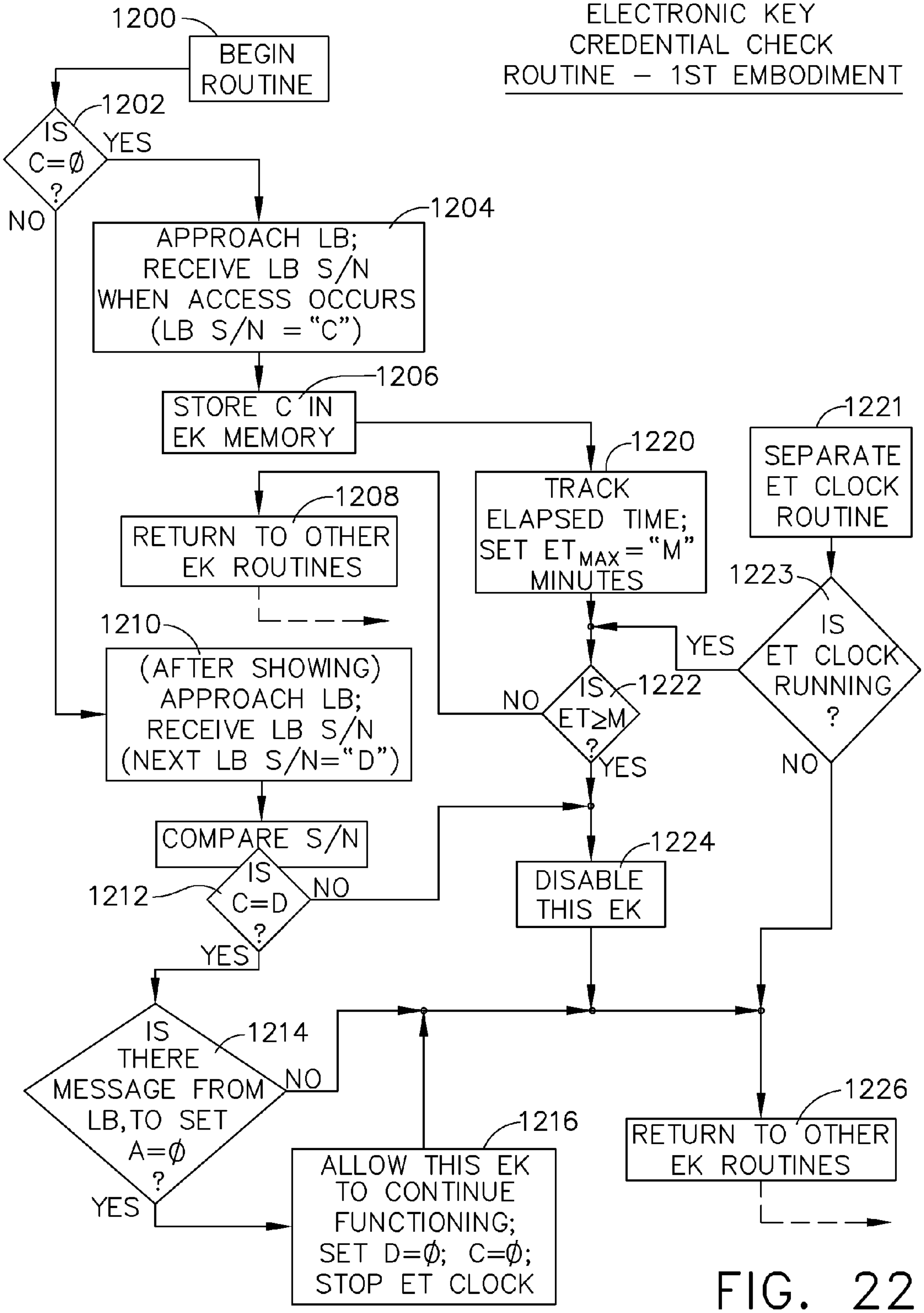

ELECTRONIC KEY CREDENTIAL CHECK ROUTINE – 1ST EMBODIMENT
1200
BEGIN ROUTINE
1202
IS C=∅ ?
YES
NO
1204
APPROACH LB; RECEIVE LB S/N WHEN ACCESS OCCURS (LB S/N = "C")
1206
STORE C IN EK MEMORY
1208
RETURN TO OTHER EK ROUTINES
1210
(AFTER SHOWING) APPROACH LB; RECEIVE LB S/N (NEXT LB S/N="D")
COMPARE S/N
1212
IS C=D ?
NO
YES
1214
IS THERE MESSAGE FROM LB,TO SET A=∅ ?
NO
YES
1216
ALLOW THIS EK TO CONTINUE FUNCTIONING; SET D=∅; C=∅; STOP ET CLOCK
1220
TRACK ELAPSED TIME; SET ET_MAX="M" MINUTES
1221
SEPARATE ET CLOCK ROUTINE
1223
IS ET CLOCK RUNNING ?
YES
NO
1222
IS ET≥M ?
NO
YES
1224
DISABLE THIS EK
1226
RETURN TO OTHER EK ROUTINES

FIG. 22

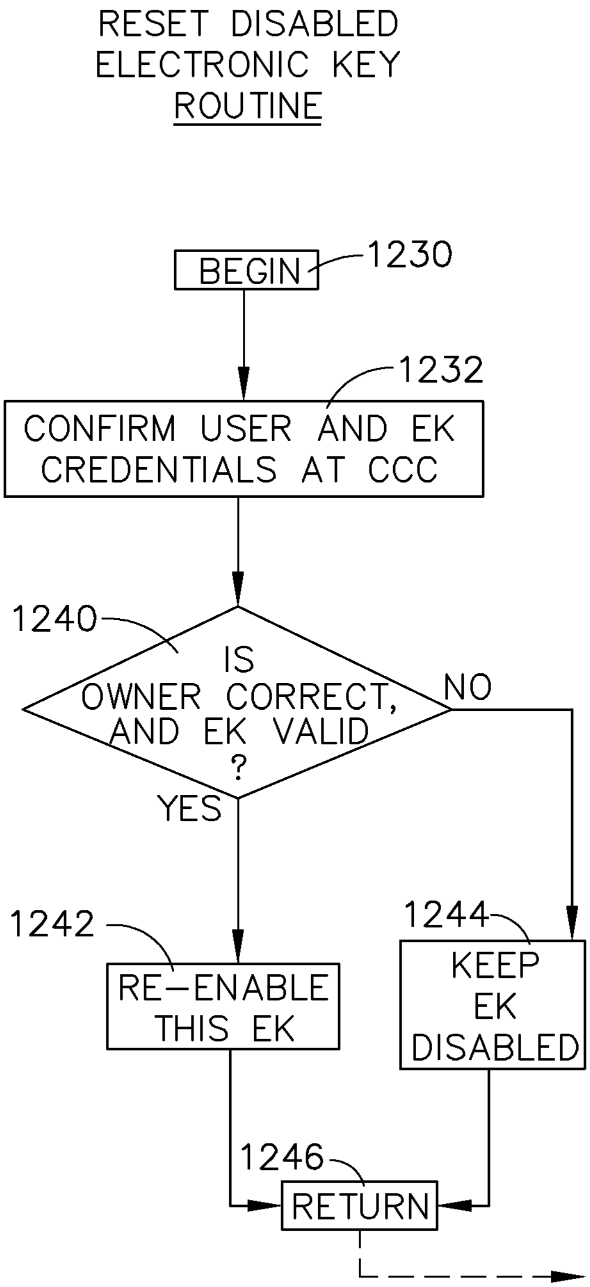

RESET DISABLED
ELECTRONIC KEY
ROUTINE
BEGIN
1230
CONFIRM USER AND EK CREDENTIALS AT CCC
1232
1240
IS OWNER CORRECT, AND EK VALID ?
NO
YES
1242
RE-ENABLE THIS EK
1244
KEEP EK DISABLED
1246
RETURN

FIG. 23

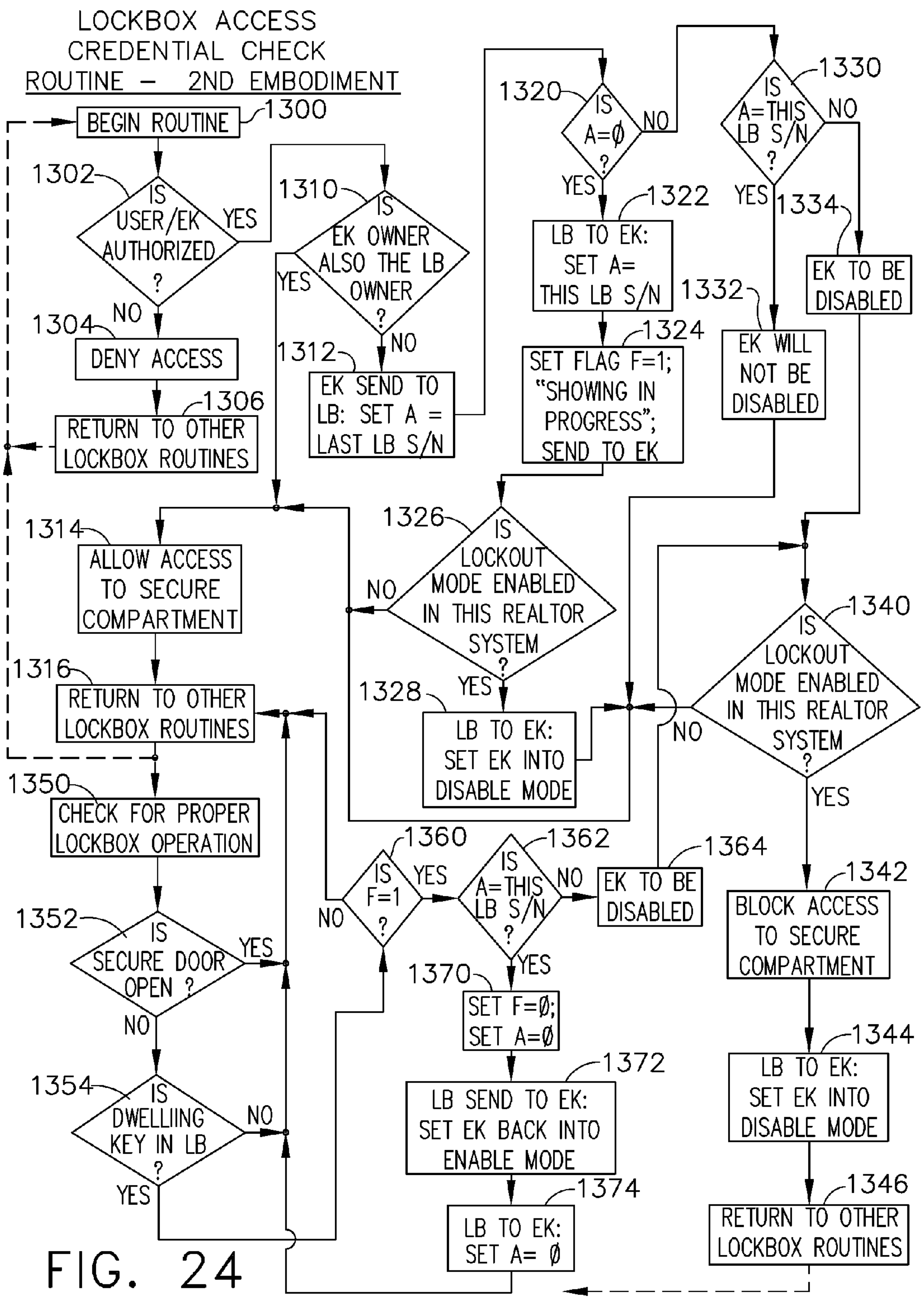

LOCKBOX ACCESS CREDENTIAL CHECK ROUTINE – 2ND EMBODIMENT
BEGIN ROUTINE
1300
1302
IS USER/EK AUTHORIZED ?
YES
NO
1304
DENY ACCESS
1306
RETURN TO OTHER LOCKBOX ROUTINES
1310
IS EK OWNER ALSO THE LB OWNER ?
YES
NO
1312
EK SEND TO LB: SET A = LAST LB S/N
1314
ALLOW ACCESS TO SECURE COMPARTMENT
1316
RETURN TO OTHER LOCKBOX ROUTINES
1320
IS A=Ø ?
NO
YES
1322
LB TO EK: SET A= THIS LB S/N
1324
SET FLAG F=1; "SHOWING IN PROGRESS"; SEND TO EK
1326
IS LOCKOUT MODE ENABLED IN THIS REALTOR SYSTEM ?
NO
YES
1328
LB TO EK: SET EK INTO DISABLE MODE
1330
IS A=THIS LB S/N ?
NO
YES
1332
EK WILL NOT BE DISABLED
1334
EK TO BE DISABLED
1340
IS LOCKOUT MODE ENABLED IN THIS REALTOR SYSTEM ?
NO
YES
1342
BLOCK ACCESS TO SECURE COMPARTMENT
1344
LB TO EK: SET EK INTO DISABLE MODE
1346
RETURN TO OTHER LOCKBOX ROUTINES
1350
CHECK FOR PROPER LOCKBOX OPERATION
1352
IS SECURE DOOR OPEN ?
YES
NO
1354
IS DWELLIING KEY IN LB ?
NO
YES
1360
IS F=1 ?
YES
NO
1362
IS A=THIS LB S/N ?
NO
YES
1364
EK TO BE DISABLED
1370
SET F=Ø; SET A=Ø
1372
LB SEND TO EK: SET EK BACK INTO ENABLE MODE
1374
LB TO EK: SET A= Ø

FIG. 24

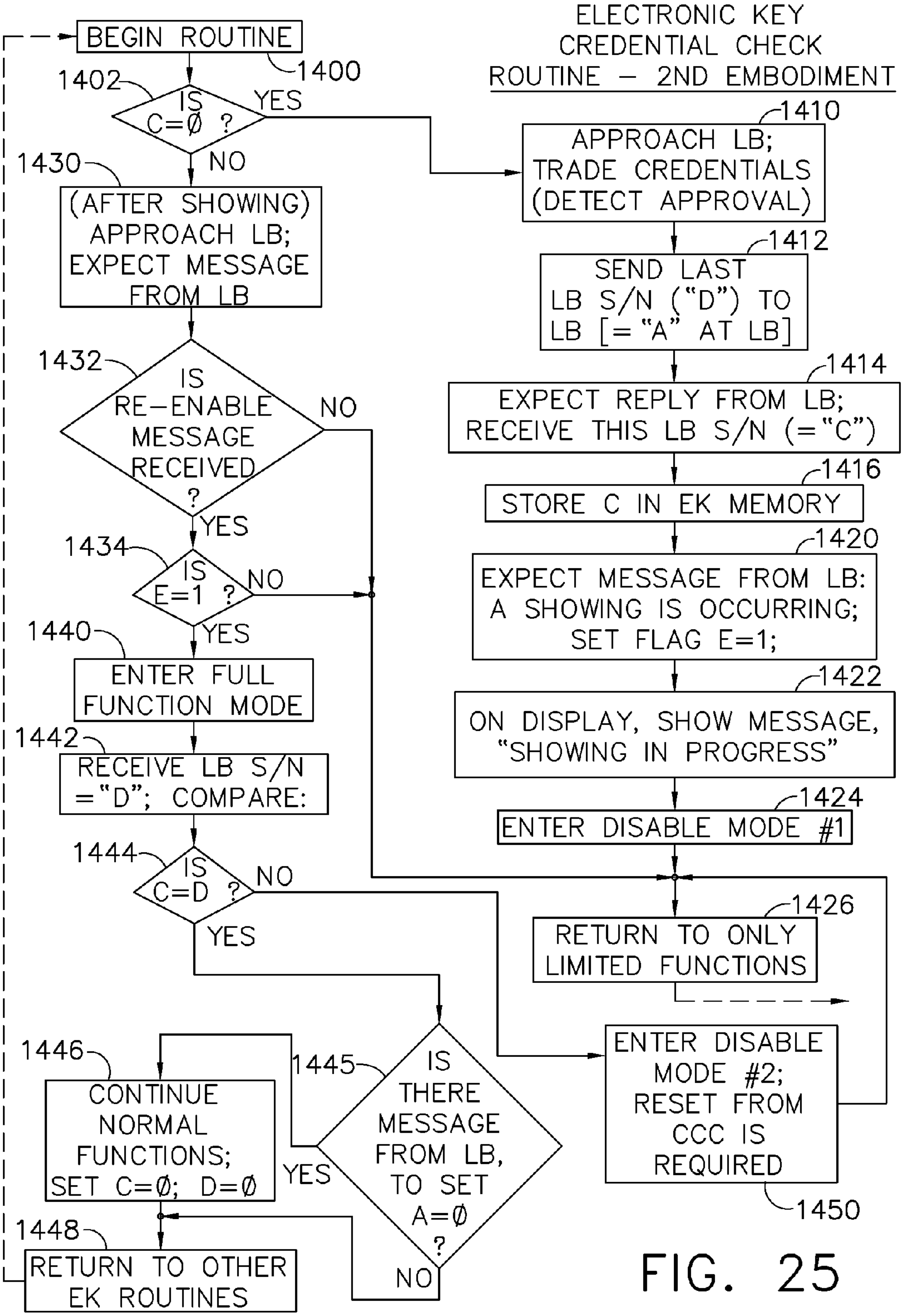

ELECTRONIC KEY
CREDENTIAL CHECK
ROUTINE – 2ND EMBODIMENT
BEGIN ROUTINE
1400
1402
IS C=Ø ?
YES
NO
1410
APPROACH LB; TRADE CREDENTIALS (DETECT APPROVAL)
1412
SEND LAST LB S/N ("D") TO LB [= "A" AT LB]
1414
EXPECT REPLY FROM LB; RECEIVE THIS LB S/N (="C")
1416
STORE C IN EK MEMORY
1420
EXPECT MESSAGE FROM LB: A SHOWING IS OCCURRING; SET FLAG E=1;
1422
ON DISPLAY, SHOW MESSAGE, "SHOWING IN PROGRESS"
1424
ENTER DISABLE MODE #1
1426
RETURN TO ONLY LIMITED FUNCTIONS
1430
(AFTER SHOWING) APPROACH LB; EXPECT MESSAGE FROM LB
1432
IS RE-ENABLE MESSAGE RECEIVED ?
NO
YES
1434
IS E=1 ?
NO
YES
1440
ENTER FULL FUNCTION MODE
1442
RECEIVE LB S/N ="D"; COMPARE:
1444
IS C=D ?
NO
YES
1446
CONTINUE NORMAL FUNCTIONS; SET C=Ø; D=Ø
1445
IS THERE MESSAGE FROM LB, TO SET A=Ø ?
YES
NO
1448
RETURN TO OTHER EK ROUTINES
ENTER DISABLE MODE #2; RESET FROM CCC IS REQUIRED
1450

FIG. 25

ELECTRONIC KEY LOCKOUT CONTROL IN LOCKBOX SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of Ser. No. 13/790,605, filed on Mar. 8, 2013, titled ELECTRONIC KEY LOCKOUT CONTROL IN LOCKBOX SYSTEM, which is a continuation-in-part to application Ser. No. 12/883,628, filed on Sep. 16, 2010, now U.S. Pat. No. 8,593,252, titled "ELECTRONIC LOCK BOX PROXIMITY ACCESS CONTROL."

TECHNICAL FIELD

The technology disclosed herein relates generally to electronic lockbox systems and is particularly directed to a system of the type that includes a portable transponder that communicates with an electronic lockbox using a low power radio link. Embodiments are specifically disclosed as a portable transponder that includes both a low power radio to communicate to the lockbox and a wide area network radio to communicate to a central clearinghouse computer; a portable transponder that includes a motion sensor to activate its wide area network radio; and a portable transponder that includes a smart card connector to communicate with a secure memory device. A further embodiment is disclosed that includes a portable transponder that communicates to an electronic lockbox using a low power radio, and communicates to a central clearinghouse computer using a wide area network radio, and also provides a secondary computer to receive messages from the clearinghouse computer over the wide area network.

Embodiments are also disclosed as a system having an electronic lockbox that sends a hail message using a low power radio that is intercepted by a wireless portable transponder, in which the hail message includes identification information corresponding to the lockbox and a user identifier; the portable transponder responds with an encrypted message that includes a time sensitive encryption key; the lockbox then authenticates this response message using its own time sensitive encryption key. If the messages are authenticated, the lockbox sends an access event record to the portable transponder using the low power radio, and this access event record is stored in a secure memory device of the portable transponder. If a wide area network is available, the portable transponder sends the access event record to the central clearinghouse computer using the wide area network radio.

Another embodiment is disclosed as an electronic lockbox system that tracks the visitation time of a property being accessed. Once the secure compartment of the lockbox has been opened, the lockbox begins to periodically transmit a PROMPT message, and if a portable transponder is in range (both using low power radios), an acknowledgement ("ACK") message is returned to the lockbox. This periodic set of messages continues until the two devices are out of range to properly receive the other's message, and the duration time of this access event is tracked by storing information in memory regarding these periodic transmissions and receptions.

Yet another embodiment is disclosed as an electronic lockbox system that enhances the security of a dwelling key at a showing of a property. When the lockbox is accessed and the dwelling key is removed from the secure compartment, the electronic key (or secure memory card) used to exchange identification information with the (first) lockbox is set into a mode to become disabled, unless that particular (first) dwelling key is properly placed back into the secure compartment of that same first lockbox, at the end of the showing. If that same electronic key (or secure memory card) is moved to a second lockbox and is used in an attempt to access its (second) dwelling key, but the first dwelling key was not properly reinstalled into the first lockbox, then the electronic key becomes disabled to the extent that it cannot be used in the attempt to obtain access to the secure compartment of the second lockbox. Various variations in control logic can be used to perform this function, as disclosed below.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

None.

BACKGROUND

Previous electronic lockbox systems that have had a portable electronic key to wirelessly communicate with the system lockboxes have required a constant battery drain at the lockbox itself, due to the requirement that the lockbox always be "listening" for a radio or light beam message that might be received at any time from the electronic key. Such lockbox systems accordingly tend to have a limited battery lifetime, and as such, the replacement of the lockbox batteries becomes a significant expense and a "nuisance" to the user, who must swap out the battery, or send the lockbox back to a dealer so that the dealer can swap out the battery. The more often a battery must be replaced, the more "down time" the user will experience per lockbox, and thus the greater the number of lockboxes that are needed by a user to maintain a specific number of operable lockboxes in the field.

In addition, previous electronic keys that have included a capability to wirelessly communicate directly with the system's central clearinghouse computer also tend to have a significant battery drain, especially those electronic keys that use cellular telephone systems as the communications link between the central computer and the electronic key. Although the batteries in the electronic keys might (typically) be rechargeable, it still can be an inconvenience for the user to have the key's battery go dead in the field, just when a lockbox is to be opened at a property site. Unless the user carries a spare (charged) battery, the user would not be able to use the electronic key to open the lockbox, thereby spoiling the showing of that property. In the conventional electronic lockbox systems, there is no backup plan to obtain access to the lockbox's secure compartment if the electronic key becomes inoperable.

SUMMARY

Accordingly, it is an advantage to provide an electronic lockbox system that includes a wireless portable transponder, in which an electronic lockbox to be accessed sends a hail message by a low power radio, and the portable transponder that is within range of the radio message will receive the hail message, and will respond with an encrypted message back to the lockbox; the lockbox hail message includes encrypted data that identifies the lockbox and the user's identification number.

It is another advantage to provide an electronic lockbox system in which a portable transponder responds to a hail message from an electronic lockbox, in which the response includes a time sensitive encryption key.

It is yet another advantage to provide an electronic lockbox system in which the electronic lockbox receives a message from a portable transponder and authenticates the received message using the lockbox's own time sensitive encryption key.

It is still another advantage to provide an electronic lockbox system in which, after an authorized access has occurred, the electronic lockbox sends an access event record to a portable transponder using a low power radio, and the portable transponder stores that access event record in a secure memory device.

It is a further advantage to provide an electronic lockbox system in which a portable transponder which has received an access event record from an electronic lockbox will now check for the availability for a wide area network, and if it is available, the portable transponder sends a message to a central clearinghouse computer in real time; and if the WAN is not available, the portable transponder queues the access event record in its memory for later transmission to a central clearinghouse computer.

It is yet a further advantage to provide an electronic lockbox system that includes a portable transponder with a motion sensor that is used to activate the wide area network radio of the portable transponder, when needed.

It is still a further advantage to provide an electronic lockbox system that includes a portable transponder, and after the transponder has been activated by a motion sensor, the transponder determines whether or not it needs to send a message to a central clearinghouse computer.

It is another advantage to provide an electronic lockbox system in which a central clearinghouse computer receives data from a portable transponder, including an access event record after one of the system lockboxes has been accessed by an authorized user, and then the central clearinghouse computer initiates a real time data push to send important information to the user of the portable transponder, either directly to the transponder, or to a secondary device, or perhaps to an e-mail server.

It is yet another advantage to provide an electronic lockbox system in which, during an authorized access event, the electronic lockbox periodically sends timed interrogation prompt messages that are acknowledged by a portable transponder that is within communication range and, so long as the two devices continue to exchange data on a periodic basis (using their low power radios), the event timing continues to advance; once the communication loop ceases, typically due to the portable transponder moving out of communication range of the lockbox, then both the lockbox and the portable transponder will record in their respective memories the duration of the event.

Yet another advantage is to cause an electronic key to be effectively disabled every time a dwelling key is accessed from a first electronic lockbox, which is designed to prevent the electronic key from being used with other lockboxes until the dwelling key has been properly re-installed into the secure compartment of the first lockbox.

Additional advantages and other novel features will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following or may be learned with the practice of the technology disclosed herein.

To achieve the foregoing and other advantages, and in accordance with one aspect, a method for operating an electronic lockbox system is provided, in which the method comprises the following steps: (a) providing a plurality of electronic lockboxes and a plurality of electronic keys; (b) of the plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of the first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within the first secure compartment; (c) of the plurality of electronic keys, providing a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device; and (d) initiating a data exchange between the first electronic lockbox and the first electronic key, using the first and second short range wireless communications devices; (i) at the first electronic lockbox, receiving a first data message from the first electronic key, the first data message containing at least one of: (A) identity information for the first electronic key, and (B) personal ID data regarding a specific human user; (ii) if a user is attempting to access the first secure compartment, then allowing access if the first electronic key's identity information and the specific user's personal ID data are authorized to access the first secure compartment, so that the predetermined dwelling key security apparatus can be removed from the first secure compartment; and (iii) temporarily disabling effective operation of the first electronic key from accessing any other of the plurality of electronic lockboxes except the first electronic lockbox, until the predetermined dwelling key security apparatus is returned to the first secure compartment, as determined by the first sensor.

In accordance with another aspect, an electronic lockbox system is provided, which comprises: (a) a plurality of electronic lockboxes and a plurality of electronic keys; (b) of the plurality of electronic lockboxes, a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of the first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within the first secure compartment; and (c) of the plurality of electronic keys, a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device; wherein the first and second processing circuits are configured: (d) to initiate a data exchange between the first electronic lockbox and the first electronic key, using the first and second short range wireless communications devices; (i) at the first electronic lockbox, to receive a first data message from the first electronic key, the first data message containing at least one of: (A) identity information for the first electronic key, and (B) personal ID data regarding a specific human user; (ii) if a user is attempting to access the first secure compartment, then to allow access if the first electronic key's identity information and the specific user's personal ID data are authorized to access the first secure compartment, so that the predetermined dwelling key security apparatus can be removed from the first secure compartment; and (iii) to temporarily disable effective operation of the first electronic key from accessing any other of the plurality of electronic lockboxes except the first electronic lockbox, until the predetermined dwelling key security apparatus is returned to the first secure compartment, as determined by the first sensor.

In accordance with yet another aspect, a method for operating an electronic lockbox system is provided, in which the method comprises the following steps: (a) providing a plurality of electronic lockboxes and a plurality of electronic keys; (b) of the plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of the first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within the first secure compartment; (c) of the plurality of electronic keys, providing a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device; (d) initiating a first data exchange between the first electronic lockbox and the first electronic key, using the first and second short range wireless communications devices; (i) at the first electronic key, receiving a first data message from the first electronic lockbox, the first data message at least containing a first identity designator for the first electronic lockbox; and (ii) storing the first identity designator in the second memory circuit; (e) at the first electronic key, beginning an elapsed time counter; (f) waiting for a second data exchange between one of the plurality of electronic lockboxes and the first electronic key, and if the elapsed time counter equals or exceeds a predetermined time value, then under the control of the second processing circuit, disabling the first electronic key; and (g) waiting for a second data exchange between one of the plurality of electronic lockboxes and the first electronic key, and if the elapsed time counter does not equal or exceed the predetermined time value, then allow the first electronic key to continue normal functions; (i) upon initiating the second data exchange between one of the plurality of electronic lockboxes and the first electronic key; (ii) at the first electronic key, receiving a second data message from one of the plurality of electronic lockboxes, the second data message at least containing a second identity designator for an electronic lockbox; and (iii) determining if the second identity designator is equal to the first identity designator, and: (A) if so, then under the control of the second processing circuit, allowing the first electronic key to continue normal functions; (B) if not, then under the control of the second processing circuit, disabling the first electronic key.

In accordance with still another aspect, a method for operating an electronic lockbox system is provided, in which the method comprises the following steps: (a) providing a plurality of electronic lockboxes and a plurality of secure memory cards; (b) of the plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a data entry device, a first card reader circuit, a first secure compartment having a first movable opening element that is under the control of the first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within the first secure compartment; (c) of the plurality of secure memory cards, providing a portable first secure memory card having a second memory circuit, and a card reader interface; (d) initiating a data exchange between the first electronic lockbox and the first secure memory card, using the card reader circuit and the card reader interface; (i) at the first electronic lockbox, retrieving first data from the first secure memory card, the data containing at least one of: (A) identity information for the first electronic key, and (B) personal ID data regarding a specific human user; (ii) if a user is attempting to access the first secure compartment, then allowing access if the first secure memory card's identity information and the specific user's personal ID data are authorized to access the first secure compartment, so that the predetermined dwelling key security apparatus can be removed from the first secure compartment; and (iii) temporarily disabling effective operation of the first secure memory card from accessing any other of the plurality of electronic lockboxes except the first electronic lockbox, until the predetermined dwelling key security apparatus is returned to the first secure compartment, as determined by the sensor.

Still other advantages will become apparent to those skilled in this art from the following description and drawings wherein there is described and shown a preferred embodiment in one of the best modes contemplated for carrying out the technology. As will be realized, the technology disclosed herein is capable of other different embodiments, and its several details are capable of modification in various, obvious aspects all without departing from its principles. Accordingly, the drawings and descriptions will be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the technology disclosed herein, and together with the description and claims serve to explain the principles of the technology. In the drawings:

FIG. **1** is a schematic block diagram of the electrical components of an electronic lockbox, as constructed according to the principles of the technology disclosed herein.

FIG. **2** is a diagrammatic view of the major components of a first embodiment of an electronic lockbox security system, including a central computer station, a wireless portable transponder device, and a portable electronic lockbox apparatus such as that depicted in FIG. **1**.

FIG. **3** is a diagrammatic view of the major components of a second embodiment of an electronic lockbox security system, including a central computer station, a wireless portable transponder device, a wireless portable secondary computer, and a portable electronic lockbox apparatus such as that depicted in FIG. **1**.

FIG. **4** is a flow chart of the steps performed by an access request routine, as used by the electronic lockbox security system of FIG. **2** or FIG. **3**.

FIG. **5** is a flow chart of the steps performed by an access event routine, as used by the electronic lockbox security system of FIG. **2** or FIG. **3**.

FIG. **6** is a flow chart of the steps performed by a portable transponder wakeup routine, as used by the electronic lockbox security system of FIG. **2** or FIG. **3**.

FIG. **7** is a flow chart of the steps performed by a real-time data push routine, as used by the electronic lockbox security system of FIG. **2** or FIG. **3**.

FIG. **8** is a flow chart of the steps performed by a visitation time routine, as used by the electronic lockbox security system of FIG. **2** or FIG. **3**.

FIG. **9** is a block diagram showing some of the major hardware components of an electronic lockbox that communicates with a wireless portable electronic key, such as a "smart phone," and that also communicates with an identification device, such as an RFID transceiver circuit, as constructed according to the principles of the technology disclosed herein.

FIG. **10** is a block diagram showing some of the major hardware components of a portable electronic key that is capable of wireless communication with one of the electronic lockboxes of FIG. **1** or FIG. **9**, for example, and that is capable of wireless communication with a wide area network, such as a cellular telephone system.

FIG. **11** is a perspective view of a stationary electronic lockbox, which includes the hardware components that are depicted in FIG. **1** or FIG. **9**, for example.

FIG. **12** is a side view of a mechanical key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, in which the key has a security tag that includes a RFID chip.

FIG. **13** is a side view of a mechanical key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, in which the key has a security tag that includes an electronic security circuit with a sense loop.

FIG. **14** is a side view of a mechanical key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, wherein the key has a security tag that includes an electrical circuit that makes electrical contact with the key, in which the electrical conductivity of the key completes an electrical "sense" circuit.

FIG. **15** is a side view of a mechanical key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, in which the key has a bar code security tag, which can be read by a bar code scanning device, and thereby forms something of an "optical sense loop" to increase security.

FIG. **16** is a side view of the mechanical key of FIG. **15**, in which the bar code has been rendered unreadable by action of a dye or ink that is activated by the removal of the bar code security tag from the key.

FIG. **17** is a side view of a modern automobile-type key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, in which the key has both mechanical surfaces for opening a mechanical lock of a dwelling or an automobile, and also has electrical pushbuttons for communicating with an electronic lock of a dwelling or an automobile.

FIG. **18** is a side view of a newer automobile-type key for use with an electronic lockbox, as constructed according to the principles of the technology disclosed herein, in which the key has a built-in wireless identification device (such as an RFID tag) for opening an electronic lock of a dwelling or an automobile, and also has electrical pushbuttons for communicating with the same electronic lock of a dwelling or an automobile.

FIG. **19** is a generalized memory map of the memory circuit of an electronic lockbox, for use in the technology disclosed herein.

FIG. **20** is a generalized memory map of the memory circuit of a portable electronic key, for use in the technology disclosed herein.

FIG. **21** is a flow chart of some of the steps executed by an electronic lockbox to perform a "Lockbox Access Credential Check" routine, for a first embodiment of logic control.

FIG. **22** is a flow chart of some of the steps executed by a portable electronic key to perform an "Electronic Key Credential Check" routine, for a first embodiment of logic control.

FIG. **23** is a flow chart of some of the steps performed by a central clearinghouse computer to execute a "Reset Disabled Electronic Key" routine.

FIG. **24** is a flow chart of some of the steps executed by an electronic lockbox to perform a "Lockbox Access Credential Check" routine, for a second embodiment of logic control.

FIG. **25** is a flow chart of some of the steps executed by a portable electronic key to perform an "Electronic Key Credential Check" routine, for a second embodiment of logic control.

DETAILED DESCRIPTION

Reference will now be made in detail to the present preferred embodiment, an example of which is illustrated in the accompanying drawings, wherein like numerals indicate the same elements throughout the views.

It is to be understood that the technology disclosed herein is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The technology disclosed herein is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless limited otherwise, the terms "connected," "coupled," and "mounted," and variations thereof herein are used broadly and encompass direct and indirect connections, couplings, and mountings. In addition, the terms "connected" and "coupled" and variations thereof are not restricted to physical or mechanical connections or couplings.

In addition, it should be understood that embodiments disclosed herein include both hardware and electronic components or modules that, for purposes of discussion, may be illustrated and described as if the majority of the components were implemented solely in hardware.

However, one of ordinary skill in the art, and based on a reading of this detailed description, would recognize that, in at least one embodiment, the electronic based aspects of the technology disclosed herein may be implemented in software. As such, it should be noted that a plurality of hardware and software-based devices, as well as a plurality of different structural components may be utilized to implement the technology disclosed herein.

It will be understood that the term "circuit" as used herein can represent an actual electronic circuit, such as an integrated circuit chip (or a portion thereof), or it can represent a function that is performed by a processing device, such as a microprocessor or an ASIC that includes a logic state machine or another form of processing element (including a sequential processing device). A specific type of circuit could be an analog circuit or a digital circuit of some type, although such a circuit possibly could be implemented in software by a logic state machine or a sequential processor. In other words, if a processing circuit is used to perform a desired function used in the technology disclosed herein (such as a demodulation function), then there might not be a specific "circuit" that could be called a "demodulation circuit;" however, there would be a demodulation "function" that is performed by the software. All of these possibilities are contemplated by the inventors, and are within the principles of the technology when discussing a "circuit."

Referring now to the drawings, FIG. **1** illustrates an exemplary embodiment of an electronic lockbox generally designated by the reference numeral **10**, which is suitable for use with the technology disclosed herein. Lockbox **10** has an outer housing, which includes a keypad **14** (see FIG. **2**), and the housing includes a movable key compartment door **32** (see FIG. **2**). The upper housing of lockbox **10** includes two receptacles (not shown) that receive a shackle **40** (see FIG. **2**). The shackle **40** has an upper portion **46** and two shackle extensions (not visible in FIG. **2**) that fit through the receptacles. It should be noted that the keypad **14** may also be referred to as a "data input device," in which a human user may press one or more of the keys to enter data, such as numeric information.

The electronic circuitry of electronic lockbox **10** is illustrated in block diagram form in FIG. **1**. In this illustrated embodiment, electronic lockbox **10** includes a microprocessor (CPU) **16**, FLASH memory **21**, random access memory (RAM) **22**, EEPROM (electrically erasable programmable read only memory) **23**, a battery (or other electrical power supply) **18**, a memory backup capacitor **26**, an ISO-7816 smart card connector **17**, indicator LED lamps **19**, a piezo buzzer **20**, a crystal oscillator **15**, a digital temperature sensor **11** (these last two devices can be combined into a single chip), a shackle drive circuit **24**, a shackle release mechanism **13**, a key compartment mechanism drive circuit **25**, a key compartment lock/release mechanism **12**, and a membrane style keypad **14** for user data entry. An impact sensor **56** can also be included in electronic lockbox **10**, to detect abnormal mechanical forces that might be applied to the device.

An input/output (I/O) interface circuit **30** is included to provide signal conditioning as needed between the CPU **16** and other components that typically use voltage and/or current levels that are not typically able to hook up directly to a processing device, such as sensors and output device driver circuits. Each appropriate I/O signal is directed through a separate channel of the I/O interface circuit **30**, unless perhaps more than one signal of a particular voltage and current rating can be multiplexed, in which case a multiplexer circuit can be included in the I/O interface circuit **30**. The data signals between I/O circuit **30** and the CPU **16** run through a low voltage signal bus **31**.

A data interface in the form of a low power radio **27** is included in this embodiment so that the CPU **16** is able to communicate with other external devices, such as a separate portable transponder **100** (see FIG. **2**) that uses a compatible wireless data link. (The portable transponder can also be referred to as an "electronic key" or a "smart phone" in some embodiments of this technology.) The portable transponder **100** also includes a low power radio **127**, which communicates with radio **27** using a protocol that could be proprietary, if desired. However, the radios **27** and **127** could use any number of various communications protocols, such as BlueTooth, although the data structure in the messages between radios **27** and **127** certainly could be encrypted, or otherwise formatted in a proprietary manner. Radios **27** and **127** further could comprise other types of wireless communications devices that may not operate on a strictly radio principle, including types of wireless communications devices that have not been invented as of yet. In this description, such wireless communications devices will typically be referred to as "radios;" however, in this patent document they may also be referred to as a "short range wireless communications device," or a "low power wireless communications device."

Microprocessor **16** controls the operation of the electronic lockbox **10** according to programmed instructions (electronic lockbox control software) stored in a memory device, such as in FLASH memory **21**. RAM memory **22** is typically used to store various data elements such as counters, software variables and other informational data. EEPROM memory **23** is typically used to store more permanent electronic lockbox data such as serial number, configuration information, and other important data. It will be understood that many different types of microprocessors or microcontrollers could be used in the electronic lockbox system **10**, and that many different types of memory devices could be used to store data in both volatile and non-volatile form, without departing from the principles disclosed herein. In one mode of an exemplary embodiment, the electronic lockbox CPU **16** is an 8-bit Atmel Mega8 microcontroller that incorporates RAM **22**, FLASH memory **21** and EEPROM memory **23** internally (as on-board memory).

Battery **18** provides the operating electrical power for the electronic lockbox. Capacitor **26** is used to provide temporary memory retention power during replacement of battery **18**. It will be understood that an alternative electrical power supply could be used if desired, such as a solar panel with the memory backup capacitor.

As noted above, electronic lockbox **10** includes a shackle **40** that is typically used to attach the box **10** to a door handle or other fixed object. Electronic lockbox **10** also includes a key compartment which typically holds a dwelling key (not shown), and which can be accessed via the key access door **32** (which is also referred to herein as a "controlled access member").

The key compartment lock and release mechanism **12** uses a gear motor mechanism (not shown) that is controlled by drive circuit **25** that in turn is controlled by CPU **16**. Shackle release mechanism **13** also uses a gear motor, which is controlled by drive circuit **24** that in turn is controlled by CPU **16**. It will be understood that the release or locking mechanisms used for the shackle **40** and key compartment **32** can be constructed of many different types of mechanical or electromechanical devices without departing from the principles disclosed herein.

The crystal oscillator **15** provides a steady or near-constant frequency (e.g., at 32.768 kHz) clock signal to CPU **16**'s asynchronous timer logic circuit. The ISO-7816 smart card connector **17** connects to electrical contacts on a "smart card" **70** to allow the exchange of data between the electronic lockbox's CPU **26** and memory devices **71** in the smart card **70** (discussed below in greater detail). The smart card **70** itself typically will include some control logic circuits **72**, to prevent "easy" or unauthorized access to the memory elements **71** on-board the card **70**.

It should be noted that an electronic key (such as that described above) could be used as a type of secure memory device for the element at reference numeral **70**, rather that a classic "smart card." Such an electronic key would also contain memory elements **71**, and perhaps would contain some control logic circuits **72**, although the control logic circuits might be optional, depending on the type of electronic key device that is used. With regard to FIG. **1**, if an electronic key is used, it could be interfaced to the CPU circuit **16** of the electronic lockbox **10** is many different ways, including via an electrical circuit that makes contact between the lockbox **10** and the electronic key **70** (similar to that depicted on FIG. **1**), or perhaps via an electromagnetic signal such as a short range radio wave, or an optical signal. As used herein, the term "electronic key" can have a meaning to include a relatively simple device, such as a secure memory card (or a "smart card"), and it can have a meaning to include a sophisticated device, such as a laptop computer or a smart phone that has a wireless communications circuit to send and receive messages from other devices, including an electronic lockbox and/or a central clearinghouse computer. A "typical" electronic key will generally be a more sophisticated device.

In one embodiment, the digital temperature sensor **11** is read at regular intervals by the electronic lockbox CPU **16** to determine the ambient temperature. Crystal oscillator **15** may exhibit a small change in oscillating characteristics as its ambient temperature changes. In one type of crystal oscillator device, the oscillation frequency drift follows a known parabolic curve around a 25 degrees C. center. The temperature measurements are used by CPU **16** in calculating the drift of crystal **15** and thus compensating for the drift and allowing precise timing measurement regardless of electronic lockbox operating environment temperature. As noted above, a single chip can be used to replace the combination of crystal oscillator **15** and temperature sensor **11**, such as a part number DS32KHZ manufactured by Dallas Semiconductor.

The LED indicator lamps **19** and piezo buzzer **20** are included to provide both an audible and a visual feedback of operational status of the electronic lockbox **10**. Their specific uses are described in detail in other patent documents by the same inventor, as noted below.

The impact sensor **56** can be used to notify an external device, in case of an attempted removal or other type of damage being done to the lockbox **10**, including intentional damage. Such an external device could comprise a "base station" as described in detail in other patent documents by the same inventor, or it could comprise the portable transponder **100** that is described herein.

Backup capacitor **26** is charged by battery **18** (or perhaps by another power source) during normal operation. Capacitor **26** serves two functions, the first of which is to maintain adequate voltage to CPU **16** during either shackle drive circuit activation, or lock drive circuit activation. In an exemplary embodiment, capacitor **26** is charged from the regulated side of voltage regulator in power supply **18**, whereas all electromechanical drive current is derived from the unregulated side of power supply **18**. Capacitor **26** also maintains a stable voltage to CPU **16** during periods of high current drain on power supply **18**. The second function of capacitor **26** is to maintain CPU **16** operation and RAM memory **22** during a period when the battery **18** is replaced.

Referring now to FIG. **2**, a first embodiment electronic lockbox system, generally designated by the reference numeral **250**, is depicted. The system **250** includes one or more electronic lockboxes **10**, perhaps one or more secure memory cards (not shown on FIG. **2**), portable transponder devices **100**, a central clearinghouse computer system **260** (also sometimes referred to herein as a "CCC"), and a wireless data communications system, represented by Internet® connections **269** and **282**, and a mobile phone provider **281**. The central clearinghouse computer **260** typically will include a database **262** which contains a repository of electronic lockbox identification and attribute information, and also contains a repository of information about real estate agents. A computer **261** controls the database **262**, and includes a processing circuit and a memory circuit (in addition to any bulk memory storage devices that contain the database **262**).

Referring now to FIG. **2**, an electronic lockbox system of a first embodiment is depicted in a diagrammatic view. An electronic lockbox **10** is depicted in the lower-right corner of FIG. **2**, and is shown communicating to a portable transponder **100**. As discussed above, portable transponder **100** includes a low power radio **127** that can communicate data to and from the low power radio **27** of the electronic lockbox **10**. Some of the other components of the portable transponder **100** are depicted on FIG. **2**.

In this embodiment, portable transponder **100** includes a microprocessor (CPU) **116**, random access memory (RAM) **122**, read only memory (ROM) **123**, and an input/output interface circuit **130**. There are several devices that are in communication with the input/output (I/O) circuit **130**, as discussed immediately below.

The low power radio **127** communicates data to and from the CPU **116**, via the I/O circuit **130**. A wide area network (WAN) radio **111** is provided, and it also communicates data to and from the CPU **116**, via the I/O interface circuit **130**. Portable transponder **100** also includes a smart card connector **117**, which is essentially identical to the smart card connector **17** that is provided on the electronic lockbox **10**. Portable transponder **100** also includes a display **119**, a keypad **114**, a power supply **118** (typically a battery), and a motion sensor **156**. The motion sensor **156** provides additional capability for the portable transponder **100**, as discussed in greater detail below.

Because of its wide area network radio **111**, portable transponder **100** is able to communicate to the clearinghouse computer **260** over a wide area network (WAN), which is generally designated by the reference numeral **110**. Assuming that the mobile communications service provider **281** is a cellular telephone system, the portable transponder **100** will have the capability of essentially immediate communications with the clearinghouse computer **260** from many, many locations, including most locations where an electronic lockbox **10** has been situated. On the other hand, if a particular electronic lockbox **10** is located in a very remote area, where there is no cellular telephone connection coverage, then the wide area network **110** therefore would not reach that location, and the portable transponder **100** would not be in immediate communication with the clearinghouse computer **260**. This situation will be discussed below in greater detail.

The wide area network radio **111** further could comprise other types of wireless communications devices that may not operate on a strictly radio principle, including types of wireless communications devices that have not been invented as of yet. In this description, such wireless communications devices are sometimes referred to as "radios;" however, in this patent document they may also be referred to as a "wide area network wireless communications device," or as a "medium range wireless communications device."

In a preferred mode of the first embodiment depicted on FIG. **2**, the portable transponder **100** includes a connector **117** that is capable of accepting a secure memory card (such as a "smart card"), so that a user who typically connects his or her secure memory card directly to an electronic lockbox **10** will also be able to connect the same secure memory card to the portable transponder **100**, and have much the same results. This will be described in greater detail below. Note that the smart card connector can also be referred to as a "data interface" that communicates with a "secure memory device"—a "smart card" is an example of a secure memory device.

The first radio circuit of the portable transponder is the low power radio **127** such as Atmel's AT86RF23x series that uses a low power radio frequency signal. The portable transponder also includes a second radio circuit which is capable of longer range communications for wide area network connectivity, such as Wavecom's WISMO22x series. In a preferred embodiment, the CPU **116** will comprise a low power microcontroller, and a relatively low power visual display **119** will be provided to allow indication of operating status. The motion sensor **156** is to be included as an internal motion sensor that is coupled to the microcontroller (CPU **116**). Its capability and use is described below.

The low power communications circuit in the lockbox (e.g. low power radio **27**) provides sufficient range to enable proximal communications with a portable transponder **100** that is carried by the lockbox system user. The built in wide area communication radio of the transponder (e.g., WAN radio **111**), such as radios used by a cellular carrier, enables a host of other system features. One desirable feature of this arrangement is for individuals who access an electronic lockbox to be unencumbered with other devices. For example, real estate agents often have their hands full when approaching a lockbox, and such an agent that is equipped with a portable transponder **100** can enter a personal identification code on the keypad **114** of the portable transponder **100**. It should be noted that the keypad **114** may also be referred to as a "data input device," in which a user (e.g., "agent") may press one or more of the keys to enter data, such as numeric information.

Such an agent could initially use the portable transponder and its keypad while remaining in a vehicle, for example, and inserting their secure memory card into the connector **117** of the portable transponder **100**. In this mode, the agent can prepare his or her portable transponder to be ready to communicate his or her personal identification code from the transponder **100** to the lockbox **10** over the low power radio link (between radios **127** and **27**), and the electronic lockbox will interpret that radio signal to allow access to the key compartment door **32**. In this manner, the lockbox radio system retrieves data from the portable transponder **100** to facilitate access to the dwelling key that is contained within the secure compartment of the electronic lockbox **10**.

In another operating mode, a secure memory card that is connected to smart card connector **117** of the portable transponder **100** can have data read from the memory elements of the secure memory card **70** that is connected to the portable transponder **100**, and have that data sent to the electronic lockbox over the low power radio link, thereby having the secure memory card's data "read" by the electronic lockbox CPU **16**. Furthermore, if it is desirable to write data onto the memory elements **71** of a secure memory card **70**, that function can occur while the secure memory card is connected to the smart card connector **117** of the portable transponder **100**, by having the low power radio **27** of the electronic lockbox **10** transfer data to the portable transponder **100**, and the CPU **116** can then write data onto the secure memory card, via the smart card connector **117**. This could be accomplished to write the same types of data that would otherwise be written directly by the lockbox **10** to the secure memory card **70** as it is connected into the smart card connector **17** of the lockbox itself.

The use of secure memory cards offer many advantages with the electronic lockbox system for access to the lockbox, which is well documented in previous patents and patent applications filed by the same inventor of this patent document. To further enhance security, the lockbox can use data that the portable transponder **100** has retrieved over its wide area radio system (i.e., the WAN **110**), such as the current (real time) decryption key for use with the secure memory card. If the portable transponder loses contact with the central clearinghouse computer system **260**, or if the secure memory card is either lost or stolen, the decryption key update credentials of the portable transponder can be revoked at the central clearinghouse computer, thereby disabling further access to lockboxes by that secure memory card.

FIG. **3** illustrates a second embodiment of an electronic lockbox system that includes the central clearinghouse computer **260**, one or more portable transponders **100**, and one or more electronic lockboxes **10**. The system of FIG. **3** also includes a wide area network **110** that could use a standard cellular telephone service, if desired.

The clearinghouse computer **260** includes a computer **261** with a processor and memory, and also includes a database **262** to hold access event data as well as a myriad of other types of information used by the electronic lockbox system. The portable transponder **100** again includes a low power radio **127** and a wide area network radio **111**. The electronic lockbox **10** again includes a low power radio **27**, which communicates with the transponder's low power radio **127**.

The second embodiment system of FIG. **3** includes an additional component, which is listed thereon as "secondary computer" **200**. Secondary computer **200** includes a microprocessor (CPU) **216**, and this computer (or processing circuit) also is coupled to random access memory **222**, read only memory **223**, and an input/output interface circuit **230**. The secondary computer **200** also includes a display **219**, a keypad **214**, a power supply **218** (typically a battery), and a wide area network (WAN) radio **211**. The WAN radio **211** can also be placed in communication with the wide area network **110**, and therefore, can communicate with the clearinghouse computer **216** or the portable transponder **100** as desired.

As described above, the secondary computer **200** could be constructed as a standard commercial device, such as a wireless laptop computer, or an Internet-compatible cellular telephone (or "smart phone"), for example. The uses of the secondary computer **200** will be described below.

The configurations of the electronic lockbox systems depicted in FIGS. **2** and **3** offer new modes of operation and capabilities that were not previously available. Using the first embodiment system of FIG. **2**, an access request routine is described in a flow chart depicted on FIG. **4**. The routine begins at a step **300**, and at a step **302** the user enters his or her personal identification number on the keypad **14** of an electronic lockbox **10**. At the completion of this sequence, the electronic lockbox transmits a hail message to any portable transponders **100** that are in the area, at a step **304**. This hail message comprises an encrypted data block that identifies the specific electronic lockbox and also the PIN of this user (which was just entered on the lockbox keypad). Compatible portable transponders that are in the vicinity and receive this hail request will retrieve the data that is present on the secure memory card that is plugged into their smart card connector **117** to compare the encrypted PIN data transmitted in the hail message with the data that has been stored on the secure memory card (in the smart card connector **117**). This occurs on the flow chart of FIG. **4** at a decision step **310**, where it is determined whether a portable transponder has received the hail. If not, then the logic flow is directed back to the beginning step **300** of this routine.

If the answer is YES at step **310**, then a decision step **312** determines whether the portable transponder's stored data matches the encrypted data. If not, then the logic flow is directed back to the beginning step **300**. Otherwise, the logic flow is directed a step **314**.

Due to the number of combinations of PIN codes and the distributive nature of the electronic lockboxes in a typical system, the probability of matching more than one portable transponder is extremely remote. The particular user's portable transponder **100** which contains the secure memory card with a matching PIN code will acknowledge the lockbox hail request by transmitting back to the lockbox **10** a unique identifier, which occurs at a step **314**.

A decision step **320** now determines whether or not the lockbox **10** has received the transponder's message. If the answer is NO, and this is determined by the portable transponder, then the transponder **100** will again try to send its unique identifier message to the lockbox more than once. The number of such attempts is determined by a step **316**, which causes the step **314** to occur multiple times. On the other hand, if the lockbox **10** does receive the transponder message, then the logic flow will be directed to a step **322**.

At step **322**, the lockbox **10** instructs the portable transponder **100** to retrieve data from memory. In this instance, the portable transponder is instructed to retrieve one or more data elements from the secure memory card **70** that is connected at the smart card connector **117**. For enhanced security, data messages between the lockbox **10** and the portable transponder **100** are encrypted with the most recent time-sensitive encryption key that has been received by the portable transponder over the wide area radio communications link (WAN network **110**). This message sent by the portable transponder **100** occurs at a step **324** on the flow chart of FIG. **4**. The electronic lockbox **10** attempts to authenticate the transponder message, using the lockbox's internally generated time sensitive encryption key, at a step **326**.

A decision step **330** determines whether or not the authentication attempt by the lockbox **10** accomplishes a match. If not, the logic flow is directed to a step **332** which determines that the portable transponder **100** needs an updated encryption key. In this situation, access is not granted at a step **334**, and the logic flow is directed to the end of this routine at a step **344**. In essence, access to the secure memory card data is not being granted due to a mismatch between the portable transponder's encryption key data and the encryption key data that is provided by the electronic lockbox itself. This occurs because the portable transponder **100** has not retrieved the most recently updated decryption key from the central clearinghouse computer **260**, and therefore, access to the lockbox **10** must be denied.

On the other hand, if an authentication match occurs at decision step **330**, then access is granted at a step **340**. In this situation the portable transponder **100** will allow the electronic lockbox **10** to use the low power communication link (between the low power radios **27** and **127**) to communicate through the portable transponder to read and write data to and from the memory elements **71** of the secure memory card **70**, at a step **342**. This reading and writing data involving the secure memory card memory elements **71** will occur, just as if the secure memory card **70** was physically connected to the electronic lockbox **10** using the lockbox's on-board smart card connector **17**. However, this now occurs using the portable transponder's smart card connector **117**.

This new method for obtaining access to the lockbox's secure compartment has occurred under a "hands free" situation, which provides maximum convenience for the user. The user can manipulate the keypad data entry and install his or her secure memory card on the portable transponder **100**, while remaining in a vehicle, if desired. The user can then easily carry the transponder in a pocket or purse, while approaching the lockbox **10**. The user enters his or her PIN code on the keypad **14** of the electronic lockbox and then can physically access the secure compartment to obtain the dwelling key for entry onto the premises. The lockbox **10** will automatically send a hail message, and the portable transponder **100** will automatically answer that hail message, without the user further manipulating the portable transponder while at the lockbox. This represents the "hands free" attribute of the access request routine of FIG. **4**

After the lockbox has written and read data to and from the memory connected to the portable transponder, the logic flow is directed to the end of the access request routine, at decision step **344**.

Referring now to FIG. **5**, a flow chart is provided for an access event routine which occurs during an access event by a user of one of the system electronic lockboxes. The routine begins at a step **400**, in which access to the specific lockbox has already been granted using a portable transponder **100**. The particular electronic lockbox **10** now sends a record of this access event to the portable transponder, using the low power radios **27** and **127** of the respective system components. The data record is to be stored on a secure memory card **70** that is attached to the portable transponder (at the smart card connector **117**), and this occurs at a step **404** on FIG. **5**. The particular lockbox now instructs the portable transponder to report this access event to the central computer **260**, at a step **406**. This is to occur using the wide area network **110**, in which the portable transponder sends the message using its WAN radio **111**, which will eventually reach the clearinghouse computer **260**.

Before the access event is actually received at the central clearinghouse computer **260**, a decision step **410** first determines whether or not the WAN link is available. If not, then the logic flow is directed to a step **412** in which the access event record is queued in the portable transponder's memory. The WAN link could be unavailable due to low battery power, or perhaps the portable transponder is presently out of range of one of the cellular service areas, for example. Therefore, the access event data is queued for future transmission by the portable transponder **100**.

Once the access event record has been queued in the portable transponder **100**, a decision step **420** will be executed, in which the portable transponder will continue to determine whether or not the wide area network is available at a later time. If not, then the logic flow is directed back to step **412** where the access event record remains queued in the transponder's memory. When the WAN later does become available, then the logic flow is directed to a step **422**.

If the WAN link was available at decision step **410**, or later becomes available at decision step **420**, then step **422** will send the access event record to the central computer **260** over the wide area network **110**. The type of information that is sent to the central clearinghouse computer at step **422** includes the serial number of the lockbox that has been accessed, the user identification number that has accessed that lockbox, and a time and date stamp that indicates when the access event occurred.

Once this access event record is received at the central computer, a decision step **430** determines whether or not the central computer currently has data about this particular property for this specific user. If not, then the logic flow is directed to a step **434**, which is the end of this access event routine. However, if the central computer does have data for this user and this specific property, then a step **432** sends a message from the central computer to the user, either using the wide area network, or perhaps using electronic mail.

The type of data that is sent to the user from the central clearinghouse computer at step **432** can include a text message about certain property information including the price of the property and various information regarding showing activity of that property. After this message has been sent to the user, the logic flow reaches the end of routine step **434**.

The additional data that may be stored at the central computer and is the subject of steps **430** and **432** of FIG. **5** is an enhancement to the lockbox system, in which the central clearinghouse computer **260** can "push" such data either to the portable transponder **100**, or perhaps to a secondary wireless device such as a smart phone that is also carried by the user. This secondary wireless device is represented as the "secondary computer" **200** in FIG. **3**. This enhanced data can contain pertinent information about the property, such as recent access activity or sales-related activity, relative frequency of access to the property, secondary alarm system codes that may be needed to enter the property, and other types of important data. The enhanced data is thereby delivered in near real-time over at least one of the various wireless communication links, just after the portable transponder has sent the access event record to the central clearinghouse computer at step **422** of the flow chart on FIG. **5**.

To significantly extend battery life, a relatively sensitive motion sensor is used in the portable transponder to detect activity by its user. This is reference to the motion sensor **156** of the portable transponder **100**. One suitable motion sensor is the SignalQuest model SQ-SEN-200. Typically the only time it is desirable to communicate over the wide area radio communication link is when the user is actively engaged in accessing one of the lockboxes in the system. To save power, the portable transponder's microcontroller (e.g., CPU **116**) keeps the radios off until the motion is sensed. Most wide area communication radios draw substantial current to maintain connectivity with the wide area network, even when the device is essentially inactive with regard to supporting a desired communication functionality. In the portable transponder **100**, the motion sensor **156** is used to wake the device to see if the portable transponder should enter a period of more active communication with the central clearinghouse computer **260**.

A portable transponder wakeup routine is provided as a flow chart on FIG. **6**. The routine begins at a step **500**, and a step **502** begins with the portable transponder in its low-power or "sleep" mode, with the wide area network radio off. During step **502**, the microcontroller of the portable transponder is generally in its "sleep mode." In addition, the modem that communicates with the WAN radio also is in its "sleep mode." When active, the modem and WAN radio transmitter typically draw about one Ampere. So it can be seen that the sleep mode saves a great deal of power.

It should be noted that there could be more than one way of causing a "sleep mode" for the portable transponder's radio; for example, electrical power to the radio's transmitter stage could be interrupted by a solid state switch or an electromechanical switch (or relay), or the electrical power to the entire radio could be interrupted, if desired. In addition, except for a low power timing circuit, it also is possible to place the entire electrical circuit of the portable transponder into a "sleep mode" if desired, and periodically wake the processing circuit for a very short time period to inspect its inputs and determine if it should then perform additional functions, or immediately go back into its sleep mode. The same is true for the electrical circuits of the electronic lockbox **10**—this methodology can save a major amount of battery power for these remotely-used portable devices.

A decision step **510** determines whether or not the motion sensor detects activity. If not, then the logic directed back to the Begin Routine step **500**. In reality, nothing substantial has occurred because the microcontroller has kept the wide area network radio off and the motion sensor has not detected any activity to require a different status of the device.

If the motion sensor has detected activity at step **510**, then a step **512** requires the controller in the portable transponder **100** to determine the present status, including its communication status. Upon "waking" in response to the motion induced by the user, a decision step **520** determines whether the transponder needs to talk with the central clearinghouse computer **260**. If not, then a step **522** keeps the WAN radio off, and the logic flow is directed back to the beginning of the routine at step **500**.

In decision step **520**, some of the information that is inspected to make this determination is as follows: (a) determine the current epoch time (b) determine if an update is required for the secure memory card that is connected to the portable transponder at the smart card connector **117**; (c) determine if any data needs to be sent to the central clearinghouse computer; and (d) if either part (b) or (c) is true, activate the modem and connect wirelessly to the central clearinghouse computer to send a message establishing contact with the central computer (at step **524**).

On the other hand, if the transponder does have a need to communicate with the central computer, then a step **524** sends a message to the central computer, using the wide area network radio **111**, in order to retrieve an updated time sensitive encryption key if the portable transponder is within communication range of the wide area network **110**. A step **526** retrieves the updated time sensitive encryption key, which is in a message sent from the central computer **260** to the portable transponder **100** over the wide area network **110**.

In addition to the above, if there is any pending data at the portable transponder **100** that should be exchanged with the central clearinghouse computer **260** because of previous lockbox activity while the portable transponder was out of range of a receiver on the wide area network, that data can now be uploaded to the central clearinghouse computer. A decision step **530** determines whether or not there is any such data in the queue that should be delivered to the central clearinghouse computer. If there is no such data, then the logic flow is directed to a step **544**, which is the end of the wakeup routine for the portable transponder. On the other hand, if there is data that has been queued for the clearinghouse computer, then a step **532** uploads the queued data to the central computer, including stored access event records.

A decision step **540** determines whether or not the central computer **260** has any messages for this particular user. If not, then the logic flow is directed to the end of routine, at step **544**. If there are any messages for the user, then a step **542** will download such messages from the central computer to this portable transponder. After that has occurred, the end of the wakeup routine has been reached at step **544**.

If desired, an additional switch could be added to the portable transponder **100** to activate the microcontroller. This could be a separate "wake-up" switch, which could be connected in parallel to the motion sensor **156**. Furthermore, if the user presses any of the keys on the keypad **114**, that could also be used as an indication to activate the CPU **116** of the portable transponder **100**.

By using the motion sensor, additional power savings are enabled since this configuration avoids having the portable transponder continue to try and periodically connect to the wide area network **110**, unless the portable transponder has been physically handled (or moved) by the user. One event that could be programmed into the CPU **116** to activate the WAN radio **111** could be if the user pressed any of the keys of the keypad **114**. This could be an additional condition that could be used even if the motion sensor **156** had not detected a sufficient amount of motion to activate the WAN radio. It should be noted that the CPU **116** of the portable transponder **100** would need to be periodically activated and then quickly de-activated, so that the logical operations of the flow chart of FIG. **6** can be executed. For example, the CPU **116** could be activated once per second, just for a sufficient amount of time to see if any of its interrupt lines have been activated at that moment. If not, then the CPU could be quickly de-activated, thereby saving battery power. This type of feature is already built into the electronic lockboxes sold by SentriLock LLC.

Another advantage of the lockbox system of FIGS. **1**, **2**, and **3** is the flexibility of the removable secure memory card, also referred to herein as the "smart card." In the event that the portable transponder's battery **118** becomes depleted, the user can remove the secure memory card from the smart card connector **117** of the portable transponder **100**, and then insert that same secure memory card into the smart card connector **17** of an electronic lockbox **10**. This allows a user to immediately gain access to the lockbox, even if the user is many miles from his or her home location. And this access can occur without a lengthy round trip to replenish the battery of the portable transponder, in this "emergency" situation. Of course, the user would likely replenish the transponder's battery at the next opportunity.

Another feature of the electronic lockbox system of FIGS. **1**, **2**, and **3** is the possibility for a user to receive near real-time information updates while the user is present at a lockbox **10**. This can be a desirable feature, and is possible when using a "real-time data push" routine that is depicted in the flow chart of FIG. **7**. The routine begins at a step **600** and a decision step **610** determines if the central computer **260** has received a message from a lockbox user. If not, then the logic is directed back to the beginning step **600**. However, if the answer is YES then a step **612** causes the central computer to inspect its database **262**, searching for an identifying match of the identity of the lockbox user that it has just received a message from. This user identifier would be a type of "mobile terminal identifier" such as a cell phone number, a mobile IP (Internet Protocol) address, or some other type of unique identifier that has been stored in the database of the central clearinghouse computer. It would be preferred for the mobile terminal identifier to be a number or alphanumeric string that is automatically sent by the portable transponder, in which this string is parsed out from the other portions of the transmission that has been sent to the central clearinghouse computer **260** by the portable transponder **100**.

A decision step **620** now determines if the user identifier matches the mobile terminal identifier that has been stored in the database of the clearinghouse computer. If not, then the logic flow is directed back to the beginning of the routine at step **600**. If the answer is YES at step **620**, then a step **622** causes the central computer **260** to input the data message that is being received from this user. A decision step **630** determines if the incoming message to the clearinghouse computer **260** is an access event record from a portable transponder **100**. If the answer is YES, then the logic flow is directed to a step **634**. If not, then the clearinghouse computer **260** goes on to execute other central computer routines at a step **632** on FIG. **7**.

Step **634** stores the access event record in the central clearinghouse computer's database **262**. After that has occurred, a step **636** has the central clearinghouse computer **260** inspect its database to find the unique user communication identifier; a step **638** will prepare a message from the central computer **260** to the user, using the user's communication identifier information. This data could consist of local alarm system codes, property information such as its current price, statistical analysis of property showing activity in the area, comparative information about a visited property with others that are similarly geo-coded, medical information about an occupant in the property, special instructions for a caregiver at the property, and other pertinent information.

A step **640** now has the central clearinghouse computer **260** send a message to the user via at least one possible communication technique. This data is sent to the user's mobile terminal without intervention by the mobile user. The central clearinghouse computer can be programmed to send such message to the user's portable transponder, or to a secondary device, or to an electronic mail server. If desired, the central computer **260** could be programmed to send this message to all three of these communication channels, or to only two the three, or simply to just one of the three, as desired by the user's original set-up programming.

It should be noted that one type of information that might be sent to the portable transponder **100** and/or to the secondary device is a "feedback request," which is a survey tool (a questionnaire) that can be used by an electronic lockbox system **250** or **260** to gather more specific information about a property for sale from a "showing agent" who has visited that property with a potential customer. A "feedback response" message would be solicited by such a feedback request. The user (e.g., the showing agent) receives the feedback request message via e-mail, or through the wireless wide area network, and answers questions that are presented in the feedback questionnaire using a computer (possibly the portable transponder). Those answers are then sent to the central computer **260** as the feedback response message. This type of functionality of an electronic lockbox system is described in detail in a companion patent application, noted below, having a title, "ELECTRONIC LOCK BOX SYSTEM WITH INCENTIVIZED FEEDBACK."

The mobile terminal of step **640** could be the portable transponder **100** or a secondary portable computer **200**, which is depicted in FIG. **3**. Such a secondary portable computer would typically be carried by the user, in addition to also carrying the portable transponder **100**. The advantage to using a secondary device is having a lowered power consumption at a portable transponder itself, as well as possibly having a simplified construction for the portable transponder, which can lower its cost.

As noted above, the secondary computer device would typically be a wireless device, such as a smart phone. It also could be a wireless laptop computer, if desired by the user.

The capabilities of having a portable transponder as described herein allow additional features to be implemented in an electronic lockbox system. One advantageous feature is to provide the capability for tracking the approximate time in which a particular lockbox system user is present at the property that has been secured by a particular lockbox. Referring now to FIG. **8**, a flow chart is provided to describe a "visitation time routine."

Upon activation of the electronic lockbox keypad **14**, and then after a successful response by a portable transponder **100** to the hail request generated by the lockbox, the lockbox **10** will begin transmitting regularly timed interrogation messages to the portable transponder to determine if the transponder is still within range. This is accomplished on FIG. **8**, starting at the beginning of the routine at a step **700**, then arriving at a step **702** in which the lockbox is still in a "sleep" mode, by which the battery is in a low power state. This operating mode will change if the lockbox keypad is activated.

At a decision step **710**, the lockbox device determines if its keypad is activated, by a user pressing one or more of its keys. If not, then the logic flow is directed back to step **702** and the lockbox remains in its dormant or "sleep" state. On the other hand, if one of the keys of the keypad **14** has been depressed, then the logic flow is directed to a step **712**, and the lockbox then executes an "access request routine" to communicate with a portable transponder. This is a routine that is described in detail hereinabove, and is the subject of the flow chart of FIG. **4**.

As part of the access request routine of FIG. **4**, the system eventually determines whether or not access should be granted by the lockbox. On FIG. **8**, this is depicted by a decision step **720**, and if access is not to be granted by the lockbox, then the logic flow is directed back to step **702**, and the lockbox goes back into its "sleep" mode until its keypad is once again activated. On the other hand, if access has been granted by the lockbox, then the logic flow is directed through the YES output from step **720**, and reaches a step **722**.

At step **722**, the electronic lockbox initiates an interrogation message prompt (referred to herein as a "PROMPT message"), which is to be transmitted by its low power radio **27**, and which will likely be received by a nearby portable transponder **100**. Of course, this reception would occur only if the user who has been granted access to the lockbox actually is carrying a portable transponder that has been the subject of the access request routine that is involved with the flow chart of FIG. **4**, as noted above. The PROMPT message preferably will be a brief data stream that contains a specific identifier code for this particular electronic lockbox **10**, and/or a transaction code for this particular access event.

The first PROMPT message is followed by several more such PROMPT messages at predetermined time intervals. In general, it would be desired for periodic PROMPT messages to be sent by the lockbox, and received by the portable transponder. The time interval between each PROMPT message could be, for example, as much as once every sixty seconds, or if desired, it could be shorter, such as once every twenty or thirty seconds, for example. This could be an optional setting that can be changed by the system administrator for particular real estate board, if desired. The PROMPT message is sent at a step **724**, via the low power radio of the electronic lockbox, as noted above.

If access had been granted for this particular electronic lockbox, this specific portable transponder would have been aware of that, due to the logical functions of the access request routine of FIG. **4**. After the portable transponder has become aware that access had been granted, the portable transponder will then be expecting to receive the PROMPT message from the lockbox. A decision step **730** determines whether or not such a lockbox PROMPT message has been received at the portable transponder. If so, then a step **732** acknowledges receipt of this PROMPT message by having the portable transponder send an acknowledgement message (referred to herein as an "ACK message"), via its low power radio **127**. The electronic lockbox will be expecting to receive this ACK message within a certain time period. The ACK message preferably will be a brief data stream that contains a specific identifier code for this specific portable transponder **100**. Moreover, the ACK message could also contain an identifier code that was first created by the lockbox **10**, which acts as a transaction code for this specific occurrence of an access event.

On the other hand, if the portable transponder has not yet received the lockbox PROMPT message at position step **730**, then the logic flow is directed through its NO output to a step **734**, where the portable transponder waits for a predetermined amount of time, referred to on FIG. **8** as "N" seconds. If the electronic lockbox sends out the PROMPT messages at predetermined intervals of thirty seconds, then the portable transponder can expect to receive such PROMPT messages about every thirty seconds, and the value for N could be set to just over thirty seconds. (However, if the interval timing is programmable by a systems administrator so that the value of N could be in the range of 20-60 seconds, for example, then the value for N at the portable transponder might be hard-coded for just over 60 seconds, so that every portable transponder will work in every lockbox system.)

If the portable transponder at decision step **730** has not yet received an PROMPT message from the lockbox, and this status continues for more than N seconds at step **734**, then the logic flow is directed to a step **736**, where the portable transponder stores a "missing PROMPT" status in the memory of the portable transponder device (e.g., in non-volatile memory that could be part of the ROM memory **123** (such as in EEPROM) of the portable transponder **100**). On the other hand, if the PROMPT message was actually received by the portable transponder in less than N seconds, then the output from decision block **730** would only travel through the YES branch to the step **732**, and there would be no storing of the "missing PROMPT" status at this time in step **736**.

If step **736** has been reached and a "missing PROMPT" status is stored in the memory of the portable transponder, the portable transponder will calculate a number of intervals in which it had received the PROMPT messages, and the number of PROMPT messages that were received will be related to the amount of real time that the portable transponder was within range of this particular electronic lockbox. At part of step **736**, this time calculation will be stored in the memory of the portable transponder, and it will be a close approximation to the amount of time for a "showing" of the property by a real estate agent (or the time of a "visitation" to the property by an authorized person, for other reasons).

It should be noted that an optional feature could be used in which the duration of the PROMPT message time intervals could be shortened under certain circumstances, to give more precision to the calculation of showing time, if desired. For example, the integral motion sensor of the portable transponder (i.e., motion sensor **156**) could be used to validate that motion is occurring, and this information can be used by the portable transponder to generate its own interrogation message back to the lockbox at a shorter time interval during such motion events. This can help to define with greater precision when the portable transponder and electronic lockbox are within communication range, and when they first come out of communication range. This greater precision can then be used to more accurately determine the amount of time for the "showing" by the user of the property.

The logic flow from both steps **732** and **736** are directed to a decision step **740**, which now determines at the lockbox whether or not a portable transponder ACK message has been received. If so, then a step **742** is executed, which causes the lockbox to continue sending the periodic

PROMPT messages at the predetermined time interval. If that occurs, the logic flow is then directed to step **724** so that the lockbox will continue to send the PROMPT message, via its low power radio.

On the other hand, if the electronic lockbox **10** has not received an ACK message, then the logic flow from decision step **740** is directed through its NO output to a step **744**, where the lockbox **10** waits for a predetermined amount of time, referred to on FIG. **8** an "M" seconds. In many circumstances, the value of M will be set equal to the value of N (from step **734**), although it need not necessarily be set to be exactly equal. Once this status continues for at least M seconds, the electronic lockbox stores a "missing ACK" status in the memory of the lockbox at step **746**. This will preferably be stored in nonvolatile memory, such as the EEPROM memory **23** (see FIG. **1**). Once that occurs, a step **748** will cause the lockbox to discontinue sending the PROMPT messages, and the end of this routine will be reached at a step **750**.

As part of the step **746** in which the lockbox stores the missing ACK status, the electronic lockbox will determine the approximate amount of time that occurred for the "showing" by the authorized user of this property to which the electronic lockbox has been attached. The lockbox **10** will keep track of the number of PROMPT messages that it has transmitted to the portable transponder during this specific access event, and since the lockbox will also know the amount of time between each PROMPT message transmission, it will have the information necessary to calculate the real time of the showing event, according to when the portable transponder and lockbox stopped communicating with each other. This calculated amount of time will be very close to the actual showing time spent by the user at the property. The user typically could be a real estate agent showing a property to a prospective buyer, or perhaps an authorized person visiting the property for another reason, such as a medical professional visiting a patient at the property.

In general, this system works to have the electronic lockbox periodically send timed interrogation message and such messages will be acknowledged by a portable transponder that is within communication range, using the low power radios (which are both transmitters and receivers) in both the electronic lockbox and the portable transponder. So long as the two devices continue to exchange data on a periodic basis, the event timing continues to advance. Once the communication loop ceases, typically due to the portable transponder moving out of communication range of the lockbox, then both the lockbox and the portable transponder will record in their respective memories the duration of the event during which the two devices were successful in exchanging the interrogation and acknowledgement messages. As noted above, the resolution of the timing (and thereby the accuracy of the system) can be affected by the interval of transmission of the interrogation messages, and if desired, this may be tuned by adjusting the interval period.

As an alternative, the electronic lockbox could track the epoch time for both the beginning of the access event and the end of this routine, to provide a different way of tracking the showing time. The electronic lockbox will know the epoch time when it began to send the PROMPT messages at step **722**, and will also know the later epoch time when its step **740** determined that there has been no ACK message received within the appropriate time interval (as determined by step **744**, by the value of M). These two epoch times could be subtracted from one another, and the difference value could be converted into real time minutes/seconds. The portable transponder could use a clock counter function in much the same manner, to provide its alternative way of tracking the showing time.

An optional, but perhaps necessary, feature of the visitation time routine of FIG. **8** will be to prevent adjacent lockboxes from affecting the timing of individual events at properties that are within close proximity to one another. To prevent this type of "crosstalk" between adjacent lockboxes, the optional function will cause a particular portable transponder to terminate an existing interrogation/acknowledgement loop from a first lockbox that was visited by a user, once the portable transponder receives a hail attempt by a different (second) lockbox. This will occur by the portable transponder refusing to acknowledge a further (existing) interrogation by the first lockbox, once the hail attempt has been received from the second lockbox. Once that occurs, then a new interrogation/acknowledgement loop will begin that involves the same portable transponder, but this time with the second lockbox, and not the first.

A variety of radio communications schemes can be employed to improve accuracy and reduce the chance of false events. Examples of such schemes include clear channel assessment before transmitting an interrogation or acknowledgment, burst transmissions of repetitive frames of data to overcome spurious noise, and analysis of received signal strength in determining a cutoff for reliable timing.

The visitation time for each authorized access event can thus be stored in the memory of both the electronic lockbox **10** and the portable transponder **100**. This information can later be uploaded to a central computer (e.g., central clearinghouse computer **260**) when a user communicates to such central computer at a later time, using the same transponder **100**, or when a (perhaps different) user communicates to the central computer using a different portable transponder or a secondary computer **200**, after the information was transferred from the particular lockbox **10** to that secondary computer **200** or portable transponder **10**. Alternatively, this information could be transferred from the lockbox **10** to a secure memory device **70**, and then later uploaded to the central computer when that memory device **70** has its memory contents read by the central computer.

It will be understood that the flow chart of FIG. **8** does not precisely represent the exact computer software executable code that typically would be used for these functions in the electronic lockbox **10** and the portable transponder **100**. In the first place, each device will operate as an individual entity, and FIG. **8** is portraying the two devices working together, as if they are virtually communicating with each other's processors at every step; in reality, the two devices must communicate with each other using messages that are transmitted and received through their respective radios and I/O interfaces **30** and **130**. Such messages are treated by their receiving devices with the proper decrypting and authenticating functions, so long as the messages are formatted correctly and contain the proper encrypted codings.

In the second place, most modern microprocessors are able to use multi-tasking software, or they can be interrupt driven, and thus able to perform portions of multiple functions out of a fixed sequence. In other words, one or more of their software routines could enter a "wait state" until certain conditions are satisfied, but their processors are not literally "stuck" once they reach a particular wait state, because their other "parallel" routines are still executing (as a multitasking processor should). Therefore, on FIG. **8**, the control logic is not "stuck" at either step **734** or step **744** when no appropriate message has been immediately received.

Instead, if a new appropriate message (a "PROMPT" or an "ACK") is indeed received, then the logic flow immediately shifts to step **732** or step **742**, to continue sending further ACK messages or PROMPT messages, respectively.

Lockbox with Wireless Communications to an Electronic Key:

An alternative lockbox design is provided in FIG. **9**, which shows many of the major electronic components, generally designated by the reference numeral **800**, in a block diagram. Most of the components listed in this block diagram are also found in the earlier versions of an electronic lockbox sold by SentriLock, LLC of Cincinnati, Ohio. A brief description of these components follows:

Electronic lockbox **800** includes a microprocessor (CPU) **816**, FLASH memory **821**, random access memory (RAM) **822**, EEPROM (electrically erasable programmable read only memory) **823**, a battery (or other electrical power supply) **818**, a memory backup capacitor **826**, an ISO-7816 smart card connector **817**, indicator LED lamps **819**, a piezo buzzer **820**, a crystal oscillator **815**, a digital temperature sensor **811** (these last two devices can be combined into a single chip) a shackle drive circuit **824**, a shackle release mechanism **813**, a key compartment mechanism drive circuit **825**, a key compartment lock/release mechanism **812**, and a membrane style keypad **814** for user data entry.

A serial interface **827** is also included so that the CPU **16** is able to communicate with other external devices, such as a separate portable computer in the form of a PDA (personal digital assistant) or other type of portable computing device that uses a serial data link. For example, serial interface **827** can comprise in infrared (IR) port that communicates with a standard IR port found on many PDAs; or it could use a different communications protocol, such as BlueTooth. A low power radio **804** is included for communications with a portable electronic key (not shown on FIG. **9**). This radio **804** could have any number of types of communications protocols, including one that allows the lockbox **800** to exchange data with an electronic key in the form of a smart phone. A special software application program (an "APP") would run on the smart phone, to allow it to communicate with lockbox **800**.

Microprocessor **816** controls the operation of the electronic lockbox **800** according to programmed instructions (electronic lockbox control software) stored in a memory device, such as in FLASH memory **821**. RAM memory **822** is typically used to store various data elements such as counters, software variables and other informational data. EEPROM memory **823** is typically used to store more permanent electronic lockbox data such as serial number, configuration information, and other important data. It will be understood that many different types of microprocessors or microcontrollers could be used in the electronic lockbox **800**, and that many different types of memory devices could be used to store data in both volatile and non-volatile form, without departing from the principles of this technology. In one mode of an exemplary embodiment, the electronic lockbox CPU **816** is an 8-bit Atmel Mega8 microcontroller that incorporates RAM **822**, FLASH memory **821** and EEPROM memory **823** internally (as on-board memory).

Battery **818** provides the operating electrical power for the electronic lockbox. Capacitor **826** is used to provide temporary memory retention power during replacement of battery **818**. It will be understood that an alternative electrical power supply could be used if desired, such as a solar panel with the memory backup capacitor.

An input/output (I/O) interface circuit **802** is provided so the microprocessor **816** can exchange data and operational signals with external devices, or with integral devices to the lockbox that require greater power than can be directly supplied by the microprocessor's pinouts. This puts the I/O circuit **802** in the pathway for virtually all signals that are used in the controlling of lockbox **800**, including the data signals that are involved with the serial interface **827**, the smart card connector **817**, and the low power radio **804**.

Electronic lockbox **800** generally includes a shackle (see item **946** on FIG. **10**) that is typically used to attach the lockbox **800** to a door handle or other fixed object. However, it should be noted that stationary versions of these electronic lockboxes are now available that are permanently affixed to buildings, or other large object, and such stationary versions do not require shackles. One such stationary lockbox is illustrated in FIG. **11**—see description below.

Electronic lockbox **800** also includes a key compartment which typically holds a dwelling key (not shown), and which can be accessed via a key access door **32** (see FIG. **2**), or a key access door **944** (see FIG. **10**). Note that the structure called a "key access door" is also sometimes referred to herein as a "controlled access member." The key compartment's lock and release mechanism **812** uses a motor mechanism (not shown) that is controlled by drive circuit **825** that in turn is controlled by CPU **816**. Shackle release mechanism **813** also uses a motor, which is controlled by drive circuit **824** that in turn is controlled by CPU **816**. It will be understood that the release or locking mechanisms used for the shackle and key compartment can be constructed of many different types of mechanical or electromechanical devices without departing from the principles of the technology disclosed herein.

The crystal oscillator **815** provides a steady or near-constant frequency (e.g., at 32.768 kHz) clock signal to CPU **816**'s asynchronous timer logic circuit. The ISO-7816 smart card connector **817** connects to smart card contacts to allow the exchange of data between the electronic lockbox's CPU **816** and the memory devices in the smart card.

In one embodiment, the digital temperature sensor **811** is read at regular intervals by the electronic lockbox CPU **816** to determine the ambient temperature. Crystal oscillator **815** may exhibit a small change in oscillating characteristics as its ambient temperature changes. In one type of crystal oscillator device, the oscillation frequency drift follows a known parabolic curve around a 25 degrees C. center. The temperature measurements are used by CPU **16** in calculating the drift of crystal oscillator **815** and thus compensating for the drift and allowing precise timing measurement regardless of electronic lockbox operating environment temperature. As noted above, a single chip can be used to replace the combination of crystal oscillator **815** and temperature sensor **811**, such as a part number DS32KHZ manufactured by Dallas Semiconductor.

LED indicator lamps **819** and a piezo buzzer **820** are included to provide both an audible and a visual feedback of operational status of the electronic lockbox **800**. Their specific uses are described in detail in other patent documents by the same inventor. Backup capacitor **826** is charged by battery **818** (or perhaps by another power source) during normal operation.

Another sensor used in the present invention is the device that will detect the key security apparatus that is typically attached to a mechanical key **1011**—see FIG. **12**. This type of sensor is referred to on FIG. **9** as a key identification detector, generally designated by the reference numeral **831**. The principle of operation of the key ID detector **831** would depend upon the type of key security apparatus that is being used with the mechanical key **1011**. Referring now to FIG.

12, if the key security apparatus comprises an RFID chip **1025** with an antenna **1010**, then the ID detector **831** would be a device that emits an electromagnet signal and can detect a return response signal. This would use a transceiver, such as the transceiver **828** depicted on FIG. **9**. On the other hand, if the mechanical key **1011** is attached to a bar code tag **1035** (see FIG. **15**), then the ID detector **831** would be some type of bar code reader, which typically involves a low-power laser beam and some type of photodiode or other type of photosensor device. Such photosensor and photoemitter devices could, in a sense, be considered a transceiver.

Electronic Key:

Referring now to FIG. **10**, a block diagram is provided for showing many of the major electronic components of an electronic key, generally designated by the reference numeral **900**. Part of FIG. **10** also diagrammatically shows certain other system components, such as a wide area network **910** and an electronic lockbox **940**. This particular lockbox includes a housing **942**, a movable door **944** that covers a secure compartment beneath its surface, a shackle **946**, and a keypad **948** for entering data via a human user.

The electronic key **900** includes a microprocessor **916**, which typically has on-board memory and interface components. On FIG. **10**, the on-board memory circuit includes some RAM at **922**, and ROM (or EEPROM) at **923**. An input/output (I/O) interface circuit is depicted at **930**. These on-board hardware components can be similar to those of the electronic lockbox, if desired. However, they are more likely to be part of a smart phone, which typically has very highly capable processing power and relatively large memory capacity.

Other hardware components of electronic key **900** include a power supply **918** (typically a battery), a display **919**, a keypad **914** (which typically is part of a touch screen display, particularly if the electronic key is a smart phone and the display viewing area is large), a wide area network (WAN) radio circuit **911**, and a low power radio circuit **927**. The two radio circuits each have their own built-in antennas, as required for their broadcast and receive frequencies. The WAN radio **911** is designed to communicate with a wide area network, generally designated by the reference numeral **910**; if electronic key **900** is a smart phone, for example, then the wide area network would generally be a cellular telephone network.

The low power radio circuit **927** is designed to communicate with one of the lockboxes of the overall security system. More specifically, the lower power radio **927** will exchange data messages with the low power radio circuit **804** of an electronic lockbox **800**, as depicted on FIG. **9**, or perhaps with the low power radio circuit **27** of an electronic lockbox **10**, as depicted on FIG. **1**. In the present technology disclosed herein, these low power radio circuits **927**, **804**, and perhaps **27**, would comprise WiFi technology, particularly if the electronic key **900** is a smart phone. Of course, other communication protocols could be utilized without departing from the principles of the technology disclosed herein. As noted above, a special APP would run on the smart phone (as the electronic key **900**), to allow it to communicate with a lockbox **800**.

It should be noted that the electronic lockbox **940** can also be accessed by use of a standard SentriLock smart card, such as the secure memory card depicted at **905** on FIG. **10**. Some of the "lockout" or "disable" functions that are discussed below are applicable to both smart cards (e.g., **905**) and electronic keys (e.g., **900**). These functions are discussed in detail below, with reference to flow charts such as FIGS. **21-23**.

Another form of electronic lockbox is illustrated in FIG. **11**. A stationary electronic lockbox is generally depicted at the reference numeral **950**. Lockbox **950** has no shackle, and instead is designed to be permanently mounted to a building or other durable fixed structure, for lockbox security systems that can involve dwellings or other types of buildings used for human habitat, or for housing other items in which a protective secure access is desired. In this disclosure, lockboxes **940** and **950** will be said to contain a "dwelling key" in their secure compartments, whether the protected structure or physical area actually contains human occupants or not.

Lockbox **950** has similar structural elements as compared to lockbox **940**. There is a housing **952**, a movable door **954** that covers a secure compartment beneath its surface, and a keypad **958** for entering data via a human user. Lockbox **950** will include the same electronic components and control software as lockbox **940**, sans the shackle latch members and the shackle itself. Lockbox **950** is designed to securely communicate with an electronic key **900** or with a smart card **905**, just like lockbox **940**.

Key Security Apparatus:

The technology disclosed herein offers other improvements to conventional electronic lockbox systems. Two main system components are used: the first main component is a specially designed "key security apparatus;" and the second main component provides additional sensors to the "standard" lockbox electronics, for communicating or retrieving data from the key security apparatus, as well as additional sensor elements to determine the key compartment's latching state.

This improvement provides a greater level of security by determining if the secured object (e.g., a mechanical key) has been properly returned to the lockbox. This is in response to complaints with older lockbox technology, in which dwelling keys sometimes are not replaced in the key compartment, either intentionally or accidentally, thus creating concern for the homeowner and inconvenience for real estate agents or contractors later attempting to access the key.

The key security apparatus can be as simple as a bar code decal on a key fob, or the key fob may contain electronic circuitry to provide a unique identification number, in the form of a signal for example, when communicating with the lockbox controller. This communication between the lockbox microcontroller and the key fob can be performed via, for example, an analog or digital RF (radio frequency) signal, an infrared link, a bar code detection scheme, a sense loop, or through an RFID-type communication system. To prevent tampering with the system, one of at least two methods can be employed to ensure that a fake key is not attached to the key security apparatus, and also to potentially identify if the key has possibly been copied.

A first method allows for a disposable key identification device in the form of passive electronics and an antenna that provide a unique response to an RF signal, in the form of inexpensive RFID (radio frequency identification) tags **1023** (see FIG. **12**). The disposable key security apparatus **1023** is designed in such a way so that it will be rendered inoperable (in an unreadable state) if it is removed from the key (or other object) **1028** that it is attached to. This can be accomplished, for example, by utilizing an antenna wire **1022** that loops through the key ring hole **1012** (or other opening in the object; see FIG. **13**), or perhaps using a fiber optic cable as the "antenna loop." The antenna loop could merely be a wire **1022** acting as an electrical conductor to complete an electrical circuit, or the antenna loop could indeed comprise an antenna **1010**, such as an antenna used in an RFID tag. To remove the key (or other object) from the key security apparatus (e.g., on the key fob), the antenna loop must be cut or otherwise detached from the key, thus breaking the electrical circuit or otherwise rendering the communication link inoperable.

In the embodiment of FIG. **12**, the key assembly generally designated by the reference numeral **1028** includes a tag subassembly **1023**. This tag subassembly has an RFID chip **1025**, with an antenna portion **1010** and electrically conductive foil paths **1024** that connect between the RFID chip **1025** and the antenna portion **1010**. If the RFID tag subassembly **1023** is physically removed from the mechanical key **1011** of this total assembly **1028**, it would have to be by clipping or otherwise cutting the antenna portion **1010**, or breaking one portion of the antenna **1010** so that it can come free from the rest of the ID tag **1023** and therefore can be removed from the opening **1012** in the key **1011**. By creating an open circuit by cutting or otherwise pulling apart the antenna portion **1010**, the RFID tag subassembly **1023** will become non-operable, and the sensing circuitry will know that something untoward has happened to the key assembly **1028**. In the embodiment of FIG. **12**, the only way to remove the key security apparatus subassembly **1023** from the mechanical key **1011** is to cut or otherwise separate the antenna **1010**, or to literally cut a slot in the mechanical key **1011** to allow the antenna to become separated physically from the key **1011**. Of course, someone will eventually notice the destructive slot in the key **1011** and this will immediately bring suspicion onto the previous users of the electronic lockbox that accessed this particular key assembly **1028**.

With respect to the embodiment of FIG. **13**, the mechanical key assembly is generally designated by the reference numeral **1020**, and includes a mechanical key **1011** that has an opening **1012**. In this key assembly **1020**, there is a key security apparatus subassembly **1015** that contains a microcontroller **1021** with an "antenna loop" **1022**. A small battery **1027** powers the microcontroller **1021**, and a transceiver circuit **1026** allows for external communications to and from microcontroller **1021**, using the antenna loop **1022**. In the embodiment of FIG. **13**, the only way to remove the key security apparatus subassembly **1015** from the mechanical key **1011** is to cut or otherwise separate the antenna loop **1022**, or to literally cut a slot in the mechanical key **1011** to allow the antenna loop **1022** to become separated physically from the key **1011**. Of course, someone will eventually notice the destructive slot in the key **1011** and this will immediately bring suspicion onto the previous users of the electronic lockbox that accessed this particular key assembly **1020**.

If the antenna **1022** is cut or otherwise mangled and separated at the microcontroller, then the transceiver **1026** will no longer be able to communicate with external devices, and the key assembly **1020** will no longer function properly. The electronic lockbox will notice this, when it tries to communicate with the key assembly **1020**, and will act accordingly. In FIG. **13**, the subassembly **1015** can be in the form of a "key fob," which contains other components therewithin, such as the microcontroller **1021** and transceiver **1026**.

An alternative methodology could use a bar code label that is fabricated in such a way as to become unreadable upon peeling or cutting it off the key or object. For example, the bar code label could be made of a material that releases a dye or other chemical that alters the color of the label if the label is tampered with (e.g., if it is cut or torn from the key). The chemical could cause the white areas of a bar code label to turn black, for example, thereby making it impossible for the bar code to later be inspected by a bar code reader.

An example of this alternative methodology is illustrated in FIG. **14**, by which there is a mechanical key assembly generally designated by the reference numeral **1054**. The two major components of the assembly **1054** are a mechanical key **1011** and a key security apparatus subassembly **1055**. In FIG. **14**, the subassembly **1055** can be in the form of a "key fob," which contains other components therewithin. In the key assembly **1054**, the key fob **1055** includes a microcontroller **1052** with a small battery **1050**, and a transceiver circuit **1053** that allows the microcontroller to communicate to an external device; these components form an "identification member" of the security apparatus **1055**.

Microcontroller **1052** has two electrically conductive leads **1051** that make electrical contact with the mechanical key **1011** at "clamping" regions **1057**. The leads **1051** extend to the front side of the mechanical key **1011**, as seen on FIG. **14**, and moreover, a portion of the leads **1051** have a second component hidden in this view that makes contact on the opposite side of the mechanical key **1011** and thereby tends to grasp the key by a clamping or spring action (again at the region **1057**, for example).

These leads form an "attachment member" of the security apparatus **1055**. Assuming the mechanical key **1011** is made of an electrically conductive material, then if the mechanical key is removed from the electrical leads **1051**, the microcontroller **1052** will sense a change of state in the electrical conductivity of the circuit path through the electrical leads **1051**. This change of state may only be temporary, but the microcontroller will be programmed to note the change of state and store it in a memory location that preferably is non-volatile. Once this has occurred, the microcontroller can send a message using the transceiver **1053** to an electronic lockbox, or to an electronic key or other type of external device that can be in communication with the transceiver **1053**, and by that methodology, it will become known that the mechanical key **1011** was removed from the electrical leads **1051**. A time and date stamp can also be stored when the lockbox notices this new status, to further narrow the possibilities of which person may have done the key removal. This information can be transferred to a central clearinghouse computer, and the REALTOR® Board will then have knowledge of this key removal incident.

It will be understood that various types of mechanical and electrical connections can be made between a pair of electrical conductors such as those designated by the reference numeral **1051** on FIG. **14**, and a mechanical key **1011**. These interconnections can even be semi-permanent, such as a small tack weld at the areas **1057** on the electrical leads **1051**, or the use of a screw; or perhaps the most useful interconnection would be some type of spring-loaded device that will provide a strong clamping action. A bend in the electrical leads **1051** to form a leaf spring effect would probably be the simplest and cheapest methodology for this mechanical/electrical interconnection.

Another alternative methodology is to provide a permanent re-codeable key security apparatus that senses its removal from the key or other object. Upon removing the key security apparatus from the key, an internal code changes or is rendered unreadable until refreshed or re-enabled through a process only available to the owner of the lockbox. One embodiment of this method is for the key security apparatus to use a metallic conductor, such as a screw, to complete an electrical circuit when the key is attached to the key security apparatus (e.g., to a key fob). In this embodiment, detaching the key security apparatus from the key would require removing the screw, which causes a circuit to be broken. When that occurs, the internal microcontroller in the key security apparatus will re-code its unique identification number, or it will otherwise disable the function of reading the identification code, until it later is re-enabled by action of the lockbox owner.

An example of this alternative methodology is depicted in FIGS. **15** and **16**. In FIG. **15**, a key assembly **1031** has two major components, a mechanical key **1011** and a bar code tag **1035**. The bar code tag **1035** has a bar code label portion at **1030**, and an extensible portion **1031** that wraps through the opening **1012** in the mechanical key **1011**. So long as the extensible portion **1031** is not traumatically disturbed, the bar code label **1030** will remain visible. However, if the extensible portion **1031** is cut or torn, the result would be the embodiment generally designated by the reference numeral **1033** as seen in FIG. **16**. The bar code tag **1035** still exists, however, an ink or dye has been released by the tearing action and obliterates the bar code label that was seen at **1032**. The extensible portion that formerly went through the opening **1012** and the mechanical key **1011** has now been cut or torn at the area **1033** on FIG. **16**. It will be understood that other methodologies for obliterating or deforming bar code labels or other visible indicia can be used without departing from the principles of the present invention.

The methods described above also allow the addition of a second security feature that inhibits the potential for covert mechanical copying of the key. The key security apparatus can be designed with sufficient "extra" material, such as plastic or metal, around the head of the key which prevents the entire key with its security apparatus from being inserted or clamped in a standard key duplicating machine. Such a structure would be difficult to remove without altering the key assembly to an extent that would raise suspicion if the altered key is later presented to a key duplicator.

With regard to the embodiment **1020** depicted in FIG. **13**, an alternative sense loop could use a fiber optic cable that passes through the opening **1012** (e.g., a hole) in the key **1011**. An LED emitter on one end of the cable could transmit pulses of light which are received at the other end by a photodetector. This optoelectronic assembly could be polled periodically by the microcontroller **1021**, and an absence of a received pulse after a transmitted pulse could then be used to determine that the key had been detached.

Another possible embodiment would use a simple contact switch (e.g., an electromechanical limit switch) that changes state when the key is present within the secure compartment. The limit switch circuit could be periodically polled by a microcontroller, if desired, or if a digital input line is available, the limit switch circuit could be directly connected into such digital input and the microcontroller would be able to directly sense a change of state in the switch's contact.

The embodiments described in connection with FIGS. **12-14** represent different types of mechanical keys that could be used in an electronic lockbox found in many real estate sales situations, as discussed above. Although the actual keys described so far have been "mechanical" keys, such as the key **1011** in FIGS. **12-14**, it will be understood that other types of dwelling keys could be used to open doors of a dwelling, and such other types of keys could be stored in the secure compartment of an electronic lockbox. Various types of non-mechanical keys will likely become popular in the future, and such keys could involve low-power radio transmitters such as the type used for unlocking automobile doors, for example, or other electromagnetic energy in the form of a low-powered light signal. See the description for FIGS. **17** and **18**, below, for such newer types of radio keys.

If the key security apparatus comprises the electrical leads **1051** with spring-loaded contacts **1057**, such as discussed above in reference to FIG. **14**, then the ID detector **831** would work through the transceiver **828**, which would communicate with the transceiver **1026** in the apparatus depicted in FIG. **13**. Certainly other types of devices could be used for the "key security apparatus" that is used for being detected by the key ID detector **831** of the electronic lockbox in FIG. **9**, without departing from the principles of the technology.

In addition to the "standard" components found in earlier electronic lockboxes by the same inventor, in the present invention an extra sensor or two is included to accomplish some of the principles of the present invention. On FIG. **9**, a door open/close sensor **830** is included, which interfaces to the microcontroller circuit **816**, via the I/O interface circuit **802**. This sensor could be a simple contact switch.

A further possibility is to measure any change in inductance when the key security apparatus is attached to the key. A sensing coil could be placed near where the key attaches, and a signal passed through the coil could be used to measure the inductance, thereby indicating the presence or absence of the key.

Except for the directly-connected limit switch contact, the aforementioned embodiments might be preferred when it is necessary (or is at least desired) to electrically isolate the key from the key security apparatus. Much of today's CMOS-based control circuits are extremely sensitive to electrostatic discharge. Having metal contacts directly contacting the key might result in undesirable operation, and so the optoelectronic embodiment, the induction coil-sensing embodiment, and the other non-contact embodiments (e.g., the RFID tag, or bar code reader) would virtually eliminate that type of problem.

One methodology for implementing a key security apparatus is to equip the electronic lockbox **800** with a small radio frequency antenna that is positioned inside the key compartment portion of the lockbox, and this would be securely hidden behind the key compartment door **32**. This situation would allow a mechanical key **1011** to be attached to a key fob type device that includes a radio frequency transceiver, such as the embodiment in FIG. **12**, in which the assembly **1028** includes an RFID chip **1025** with an antenna **1010**. Of course, this would also work with the embodiments of FIGS. **13** and **14**, which also include a microcontroller and a transceiver circuit.

In any of these designs, the low-power radio frequency signal generated by the antenna inside the key compartment would not be able to easily escape through the metal enclosure of a standard electronic lockbox, as currently manufactured by SentriLock, LLC of Cincinnati, Ohio. Therefore, for the key to be properly detected, the key (along with its RF transceiver identification device) would have to be positioned within the secure compartment of the electronic lockbox **800**. In this situation, the electronic lockbox **800** could directly determine whether or not the key assembly with its identifier tag or "key fob" is positioned within the key compartment (behind the key compartment door **32**).

In one mode of the invention, the microcontroller **816** of the lockbox **800** could periodically send a short RF transmission, and if it receives the proper response, it could deduce that the key assembly was currently positioned within the lockbox key compartment. This periodic signal could be referred to as a "polling" signal, and if designed properly, the polling signal would only elicit an appropriate response from the "key fob" (i.e., the key identifier device) if the key fob was within range and could receive the polling signal, essentially by being within the lockbox secure compartment. If the electronic lockbox sends a polling signal and the key assembly has been removed, then generally there would not be a proper response. If an unscrupulous person attempted to fool the electronic lockbox by tearing off the key fob and leaving it inside the secure compartment, then because of the circuitry discussed above, there would still not be a proper response from the key security apparatus, such as the "key fob" apparatus **1023** of FIG. **12**, the "key fob" apparatus **1015** of FIG. **13**, or the "key fob" apparatus **1055** of FIG. **14**. Since there are appropriate countermeasures in the design of the present invention, the unscrupulous person would be defeated in this attempt to fool the electronic lockbox.

Referring now to FIG. **17**, a modern style automobile-type key is generally designated by the reference numeral **1040**. Key **1040** has both a mechanical key component and an electronic key component. It has a standard key shape with mechanical lock-style keyed surfaces at **1041**, and it has an electronic circuit portion on the opposite side of the key, at **1042** on FIG. **17**. This type of key will typically have at least two pushbuttons, and on FIG. **17** they are depicted at **1043** and **1044**. Such pushbuttons are generally for locking or unlocking the doors of a vehicle, such as an automobile. Many of these types of keys also have additional pushbuttons possibly for unlocking the trunk, or perhaps as an emergency alarm button. This type of key could also have an identifier built within the electronic circuit portion **1042**. That identifier could be a standard RFID chip at **1046**, for example, or some other type of identification device that uses a radio circuit.

Referring now to FIG. **18**, a yet newer style automobile-type key is depicted, generally designated by the reference numeral **1050**. In this key **1050**, there is no mechanical-type surface for unlocking any type of mechanical lock. Instead, this type of key is electrically operated only, and has an electronic circuit to communicate to an automotive-type vehicle. Such keys typically have four pushbuttons, and on FIG. **18** those pushbuttons are designated at **1052**, **1053**, **1054**, and **1055**. The key **1050** also has an RIFD chip at **1056**, or some other type of electronic device used as an identifier, which could be some other type of radio operated circuit.

Both of these automotive-style keys in FIGS. **17** and **18** could be used with an electronic lockbox of the type generally depicted in FIG. **9**. One of the pushbuttons could be used to open the door lock of a dwelling-style building, such as a house or an apartment. Another one of the pushbuttons could be used for locking such electronic lock of the dwelling. This type of technology might already be in place in some dwellings of newer construction.

All the above-discussed keys and/or key fobs can be generally described by the phrase, "dwelling key security apparatus." More specifically, such an apparatus will comprise a combination of a dwelling key and some type of specific identifier device that either is attached to, or contained within, the dwelling key. If a particular such apparatus is being discussed as having a relationship to a specific lockbox, that apparatus can be referred to as a "predetermined dwelling key security apparatus." In other words, if a predetermined dwelling key security apparatus came out of the secure compartment of "lockbox #1," then that same predetermined dwelling key security apparatus is later supposed to placed back into the secure compartment of "lockbox #1," not lockbox #2, and not to be carried off forever by a person either intentionally, or unwittingly. As such, the phrase "dwelling key security apparatus" is often used herein, including in the claims. The specific identifier device portion of this dwelling key security apparatus is of a type that can be detected by a sensor located on the lockbox; and more appropriately, the sensor would be able to detect that the predetermined dwelling key security apparatus is actually within the secure compartment of that lockbox.

Referring now to FIG. **19**, a generalized memory map of the memory circuit of a lockbox for use in the technology is depicted at the reference numeral **823**. Every electronic lockbox has its own identification data stored in its memory circuit, and this is represented at reference numeral **860**. In this technical disclosure, this type of lockbox identification data is also sometimes referred to as the lockbox serial number. Such identification data does not necessarily have to be strictly numeric, although that is a standard way of dealing with this type of identification data.

The lockbox also has a number of security settings, which are also sometimes referred to as "permissions." These are stored in the portion of the memory circuit designated at **862**. This type of data includes the real estate Board, and other types of information pertaining to the options that lockboxes in a particular real estate Board will observe. One of those options would be whether or not the "lockout mode" is enabled in this realtor system or not. That setting has an impact on some of the logic diagrams discussed below.

The next portion of the memory map at **864** is for active data that involves electronic keys. The previous "last lockbox serial number" is stored in a memory location designated as "A". The "next lockbox serial number" is stored at a memory location designated as "B". The use of these variables is described below, mainly in reference to FIGS. **21** and **22**, and also in later figures for an alternative embodiment.

The next large portion of the memory map is for lockbox use data, also sometimes referred to as access log information, and this is at the area designated by the reference numeral **866**. The next set of memory at **868** is for electronic key user credentials, and that data is stored with regard to the electronic key that presently is attempting to access the secure compartment of this lockbox.

Referring now to FIG. **20**, a similar memory map generally designated by the reference numeral **923** is provided for an electronic key, for use in the technology, as generally depicted in FIG. **10**. The identifying information for this particular electronic key is stored in a portion of the memory circuit at **960**. This would include the serial number of a particular electronic key, including if this electronic key is actually a secure memory card of the type that has been used with SentriLock system lockboxes for years. If the electronic key is a smart phone, then the electronic key ID data will be of a different type of information—e.g., a different series of numbers.

The next portion of the memory circuit at **962** is for electronic key settings, also sometimes referred to as "permissions." As with lockboxes, electronic keys are designed to work within certain REALTOR boards, and that information is stored here.

The next portion of the memory circuit at **964** is for storing active data with respect to lockboxes that are accessed by this electronic key. The previous "last lockbox access" is stored in a portion of the memory that holds a variable called "C". The "next lockbox access" is stored in a portion of the memory that holds a variable called "D"—this information "D" pertains to the present lockbox that is being accessed.

The next large portion of memory in the electronic key is for storing access logs for many different lockbox access events. This portion of memory is in the memory map at **966**. Finally, the electronic key's user credentials are stored at **968**; and this information can be transferred to the electronic lockbox and stored at its memory locations at **868** on FIG. **19**.

Control Logic for Electronic Key Disable Function:

When a real estate agent visits a dwelling and obtains possession of the dwelling key that is stored in the lockbox that has been placed at the dwelling, it is important that the dwelling key be returned to the lockbox secure compartment before the real estate agent leaves the premises. One way to help insure that this actually occurs would be to disable the electronic key (or a secure memory card) that is carried by the real estate agent during the lockbox transaction. In other words, if the real estate agent obtains possession of the dwelling key but does not return that dwelling key to the correct lockbox, then the real estate agent's electronic key will not operate to access any other lockboxes in that real estate Board system.

Referring now to FIG. **21**, a flow chart is provided for a first embodiment of the logic control for when a lockbox is accessed by an electronic key, in which the electronic key will not work with other lockboxes until the dwelling key is returned to this first lockbox. FIG. **21** is called a "lockbox access credential check routine," and shows many of the operational steps performed by the controller of the lockbox itself. There are some stages of this control logic that pass data to an electronic key, or receive data from an electronic key, but the electronic key has its own operational logic which is described on a different flow chart.

Although the logic presented on FIG. **21** shows a system that expects to have a lockbox access transaction between an electronic lockbox and an "electronic key," most of this logic will also work in the same manner if there is a secure memory card instead of an electronic key. (In this sense, a secure memory card is a type of electronic key.) One other note: the real estate Board will have an option as to whether or not this "lock out mode" shall be enabled or not for the lockboxes in that particular Board's system. If the answer is YES, then all lockboxes in that particular real estate Board will operate in this manner. If the answer is NO, then none of the lockboxes in that particular real estate Board will have this mode enabled.

The credential check routine begins at a step **1100**, and the first logic is performed at a decision step **1102**, where the lockbox determines whether or not the user and the specific electronic key that is communicating with the lockbox are authorized to access the secure compartment. If the answer is NO, then access to the secure compartment will be denied at a step **1104**. The logic flow will now return to other lockbox routines at a step **1106**.

At decision step **1102**, the answer could have been YES, but for that to occur, both the user's personal identification information has to be correct, and also the electronic key itself has to be correct with regard to its identification information. As a minimum, both the lockbox and the electronic key must have identifying data that shows they both belong to the same real estate Board. In addition, the electronic key has to be "up to date," meaning that it has been rejuvenated so that is working in the correct epoch time, such that the encrypted data that contains both the epoch time, the rejuvenation data, and the user's PIN have all been combined into the correct diversified numeric data by the hash routine, so that the lockbox will properly decrypt that information to come up with the correct user's PIN that will match the actual user's PIN data when it is entered on the keypad. This type of information will be required whether or not the electronic key is being used, or if a secure memory card is being used, because both devices will contain the same type of information. This all relates to the EK user credentials that are stored in the memory locations at **968** in the electronic key, and later in the lockbox memory at **868**.

Once the lockbox has determined that both the user and the electronic key are authorized, a step **1100** is performed by which the electronic key sends (or already sent) a message to the lockbox. The last lockbox that was visited by this electronic key had a serial number, and that information is sent to the current lockbox from the electronic key in this step **1110**; the information is placed into a variable that is referred to herein as "A". This variable A typically consists of a multi-digit numeric value, and each lockbox in the system will have a unique identifying number, which is often referred to as the "serial number" in this disclosure.

Before going farther in this flow chart, it must be understood that other functions occur in the lockbox and also in the electronic key, either in a true multi-tasking software environment, or in a sequential operating mode with each routine quickly coming to a point in its processing where it returns to the main routine to allow other operating routines to be executed. The lockbox itself has another routine that is illustrated on FIG. **21**, and is called the "check for proper operation of lockbox" routine, at a step **1150**. In this check for proper operation routine, a decision step **1152** is performed to determine if the secure door of the key compartment is open or not. Some type of sensor (e.g., a limit switch or proximity sensor) is used to determine this state of operation. If the answer is YES, then that is the end of this short routine and the logic flow returns to other lockbox routines at a step **1116**. On the other hand, if the secure door is not open, then a decision step **1154** determines whether or not the correct dwelling key is in the lockbox. For this step to be performed properly, the dwelling key must have some type of security identifier, as discussed above with respect to the various security keys that are illustrated in FIGS. **12-18**, for example. In other words, not just any mechanical dwelling key or some type of electronic dwelling key can be placed into the secure compartment; it must be the correct such key with the proper security identifying apparatus, and a sensor in the lockbox will detect that. If the answer is NO at step **1154**, then the logic flow returns to other lockbox routines at step **1116**.

On the other hand, if both of these decision steps are answered correctly, then the logic flow is directed to a step **1156** where the lockbox sends a message to the electronic key to set the value of A equal to zero. This can only occur if the secure compartment door has been closed (see step **1152**) and if the correct dwelling key is contained within that secure compartment (see step **1154**). This is the desired state of the lockbox at the end of a showing, and when the real estate agent walks away from that dwelling with the lockbox in that state, everything should be set back to its normal operating parameters. In the logic flow for this first embodiment, the way this is achieved is to essentially null out the lockbox serial number, and have zeros put into the value for the variable A. This will be important at other portions of this logic diagram in the flow chart of FIG. **21**. Once A has been set to zero, the logic flow is directed to step **1116**, where the logic returns to other lockbox routines.

Referring back to step **1110** on FIG. **21**, the electronic key is sending the value of A to the lockbox. If the electronic key has had its value A set to zero by a previous visit to a different lockbox that has gone according to normal circumstances, then A will be equal to zero at this point. A decision step **1112** now determines whether or not the owner of the electronic key is also the owner of the lockbox. If YES, then the logic flow is directed to a step **1114** that allows access to the secure compartment. This will always be true for the real estate agent who also is the lockbox owner, once that user and his or her electronic key have been authorized at step **1102**. The logic flow is now directed to return to other lockbox routines at step **1116**.

Most real estate showings are not performed by the lockbox owner, but instead by other real estate agents. In that situation, the logic flow of decision step **1112** is directed out the NO output to a decision step **1120**. At step **1120** the logic checks to see if the value of A is zero. If YES, then the lockbox sends a message to the electronic key to set a variable known as "B" to "this lockbox serial number." This function occurs at a step **1122**. In this situation, "this" lockbox is the one attempting to be accessed right now, and that lockbox's serial number is placed into the variable B. This step **1122** also sets the numeric value of A to that same lockbox serial number. This message is transmitted to the electronic key, so that both variables A and B are set to the same numeric value at the electronic key as well. (At the electronic key, these variables are called "C" and "D.") After this has occurred, the logic flow is directed to the step **1114**, and access is allowed to the secure compartment of the lockbox. This is the usual state of affairs at the beginning of a showing of a dwelling by a real estate agent. In this circumstance, the agent's electronic key initially had the value zero for its variable A, and after the lockbox was accessed, both the lockbox and the electronic key have had their variables A and B (or C and D) set to this lockbox's serial number. This information will be used later, typically at the end of the showing.

At the end of a typical showing, the logic flow travels from step **1102** through steps **1110**, **1112**, arriving at decision step **1120**. Since the value of A is not equal to zero, the logic flow is directed to a decision step **1130** where it is determined whether or not the value of A is equal to the value of B. If the answer is YES, then the logic flow is directed to a step **1132** where the electronic key is allowed to continue normal operation, and access to the secure compartment is allowed at **1114**. This is the desired scenario, and is the expected result so long as the particular electronic key has not had communication with a different lockbox in the meantime; however, if the electronic key had communicated with a different lockbox, then that lockbox's serial number would have been placed into the variable B, and thus A would not equal B for that different lockbox. In that situation, the logic flow at decision step **1130** would have been directed to a step **1134** where the electronic key will become disabled. Before that occurs, a decision step **1140** determines whether or not the lock out mode has been enabled for this realtor system. If not, then the user is allowed access to the secure compartment at step **1114**.

Assuming the lock out mode has been enabled for this real estate Board, then the logic flow will be directed to a step **1142** in which the lockbox will block access to its secure compartment in this situation. After that occurs, the lockbox sends a message to the electronic key telling the electronic key to disable itself, at a step **1144**. After that the logic flow returns to other lockbox routines at a step **1146**.

Once the electronic key has become disabled, it will not be allowed to communicate with other lockboxes and obtain access to the secure compartment of those other lockboxes. In this first embodiment of FIG. **21** the electronic key will also be disabled from talking to the original lockbox, and the user will have to initiate a communication session with the central clearing house computer for this real estate board to have this electronic key reset from the disabled mode. That logic is discussed in reference to FIG. **23**, discussed below.

The situation that this control logic is trying to prevent is simply allowing the real estate agent to walk away from the initial showing while still carrying the particular dwelling key for that first lockbox. Alternatively, the dwelling key could have been dropped and even perhaps lost, but the effect still would be that the correct dwelling key has not been returned to the secure compartment for this first lockbox. In that event, then there will be no second accessing the lockbox by the electronic key, and the values for variables A and B in that electronic key have been set to non-zero numbers that correspond to the lockbox serial number. This was for lockbox number one; when that same user with the same electronic key attempts to access a second lockbox, then the logic flow will begin at step **1100**, go through step **1102**, and at step **1110**, the electronic key will send its current value for variable A to the lockbox. Variable A represents the "last lockbox serial number", which was lockbox number one. Now that the user is accessing lockbox number two, the logic flow will be directed through steps **1112**, **1120**, and arriving at decision step **1130**. A will not be equal to B, because B is the value of the lockbox serial number for lockbox number two, and A is the value of the serial number for lockbox number one. The result will be that the logic flow is directed to step **1134** where it has been decided that the electronic key is to be disabled. The logic flow will then be directed through steps **1140**, **1142**, and **1144**, at which time the lockbox sends a message to the electronic key telling the key that it should be disabled. This electronic key will now have to be reset by the routine of FIG. **23**.

Referring now to FIG. **22**, some of the operational steps of the logic for an electronic key used with the lockbox logic illustrated in FIG. **21** are depicted, and in FIG. **22** this is referred to as the electronic key credential check routine. Beginning at a step **1200**, a decision step **1202** determines whether or not the value of a variable "C" is equal to zero. The answer to this question depends on what has happened previously in the history of this electronic key. If the electronic key is brand new, then the value of the variable C will already be set to zero. If the electronic key has previously been used with any lockbox, then the value of C will not be equal to zero during certain portions of the logic routine, but if the dwelling key has been correctly put back into the secure compartment of the previous lockbox, then a message from the lockbox should have been received by this electronic key that would have reset the value of C back to its original zero value.

Assuming the answer is YES at step **1202**, a step **1204** occurs in which the electronic key approaches a lockbox and receives the lockbox serial number when access has occurred for this lockbox encounter. This lockbox's serial number is placed into the variable C at this time, at a step **1206**. A step **1220** causes an elapsed time clock to begin running (or "counting"); see below for more details. The electronic key control logic now returns to other electronic key routines at a step **1208**. Steps **1204**, **1206**, and **1208** typically occur at the beginning of a showing, when the electronic key has communicated to a lockbox and has attempted to obtain access to the secure compartment so that the user can temporarily gain possession of the dwelling key that is contained within the secure compartment. All of this presumably will have occurred by the time the step **1208** is reached in this control logic.

Later, usually at the end of a showing, the credential check routine begins again at step **1200**, and this time at decision step **1202**, the value for C will not be zero. Therefore the logic flow is directed to a step **1210**, in which the lockbox is again approached by the electronic key and they communicate with one another, at this time the lockbox sends a serial number, and that is placed into a variable called "D", which represents the "next" lockbox's serial number. So long as the same lockbox is the one that has been communicating with the electronic key, both before and after the showing of the dwelling, then the values for C and D should be equal to one another. A decision step **1212** compares these two values to see if the value of C is actually equal to D, and if the answer is YES, then a decision step **1214** indirectly determines if the proper dwelling key has been placed back into the lockbox.

Decision step **1214** is part of the control logic for the electronic key, and its processing circuit really cannot directly determine whether or not the dwelling key is back in the lockbox's secure compartment, or whether the door of the lockbox's secure compartment is closed. But it can infer that information from a data message that the lockbox sends at step **1156** in the flow chart of FIG. **21**. In step **1156**, the lockbox tells the electronic key to set variable A to zero; that logic step only occurs if the "proper operation check" logic in steps **1150**, **1152**, and **1154** have determined that the dwelling key is back into a secure compartment, behind a closed door, of the lockbox. This message that A=0 is the result of this "proper operation" of the lockbox by its current user, and that information will eventually result in the variable C at the electronic key being reset to zero. But first, the lockbox's message must be received and analyzed by the electronic key, which occurs at decision step **1214**.

If the answer is NO at decision step **1214**, then the logic flow is directed to the "Return to Other EK Routines" step **1226**, and the electronic key will keep operating (i.e., it will not be disabled), but its variables C and D will not be reset to zero, and the elapsed time clock will continue to operate (which means that the electronic key might become disabled because it runs out of time—see the discussion below). However, if the answer is YES at decision step **1214**, then the logic flow is directed to a step **1216** allows this electronic key to continue functioning for all normal modes of operation. In step **1216**, the variables C and D are both set to zero in the electronic key, thereby readying the electronic key for the next lockbox encounter. Additionally, the elapsed time counter (or clock) is stopped as part of step **1214**. This elapsed time counter will be discussed next.

If the value for C was not equal to D at decision step **1212**, then the logic flow is directed to a step **1224**, and this electronic key will now disable itself. After that occurs, the logic flow is directed to a step **1226** in which the logic returns to other electronic key routines. However, many of the important electronic key routines will have been disabled, including the ability to communicate with lockboxes, and the ability to directly communicate with the central clearing house computer. In this circumstance, the electronic key will need to be reset. See FIG. **23**.

If the real estate agent/user forgets to return the correct dwelling key to the lockbox secure compartment we do not wish to simply allow the user to walk away from the dwelling site without there being some consequences. One of the consequences is that the electronic key will not operate with the "next" lockbox, because the value of the variable C will not be zero, and therefore this electronic key is effectively disabled from communicating with any other lockbox. However, that still is not sufficient because the electronic key could be used for many other functions besides trying to communicate with a different lockbox. Therefore, it also would be desirable for this electronic key to eventually be disabled due to elapsed time.

One of the other electronic key routines begins at a step **1220**, in which the elapsed time is "counted" or "tracked". At this step, the elapsed time maximum value, referred to herein as the variable "M" is set to a predetermined value in minutes. This will likely be a control variable that is set to the same value for all real estate agents working in this particular real estate Board system of lockboxes. For example, the value of M could be sixty minutes, ninety minutes, or even one hundred twenty minutes, if real estate agents typically take up to two hours to show a house.

In any event, once the value of M has been loaded into the elapsed counter, the elapsed timer begins counting the number of minutes that have actually elapsed since step **1206** has occurred. In other words, once the electronic key has accessed the lockbox to obtain the dwelling key, this routine **1220** begins and the elapsed time counter begins tracking the elapsed time.

A decision step **1222** now determines if the actual elapsed time has exceeded the value of M. If not, then the logic flow returns to other electronic key routines at step **1208**. However, if the elapsed time does exceed the value of M, then the logic flow is directed a step **1224** that disables this electronic key. Once that occurs, electronic key operating system will return to other electronic key routines at a step **1226**, but most of the routines will then have been disabled and the electronic key will need to be reset.

The electronic key spends most of its time doing nothing at all, or doing other functions besides those spelled out in the flow charts of this patent document. Because of that reality, a separate routine is included to keep tabs on the elapsed time clock. In other words, it is desired to have the elapsed time clock perform its disabling function as a "stand alone" function, not only when the electronic key's control logic has reached one of the flow chart steps of FIG. **22**, such as step **1206** and then step **1220**. Therefore, a separate elapsed time clock checking routine is provided, starting at a step **1221**. This routine first determines whether or not the elapsed time clock is running, or is stopped, as a decision step **1223**. If it is stopped, this routine quickly drops out by arriving at the return step **1226**. This entire clock checking routine can be re-started at step **1221** one second later, or XX seconds later, if desired, under the control of the overall computer program that runs the electronic key's processing circuit.

If the elapsed time clock is running, then the logic flow is directed from step **1223** to the decision step **1222**, which determines whether the elapsed time has reached the set-point value M. If so, then this electronic key is disabled at step **1224**. Therefore, the control logic of FIG. **22** has two routes by which the electronic key can be disabled due to elapsed time.

Referring now to FIG. **23**, if an electronic key has been disabled, it needs to be reset. This routine is referred to as the "reset disabled electronic key routine," and it begins at a step **1230**. The user will have to initiate a communications session with the central clearinghouse computer, and a step **1232** confirms the user's credentials and the credentials of the electronic key at the central clearinghouse computer (CCC). A decision step **1240** determines whether or not the owner is correct and the electronic key is a valid key for that particular real estate Board. If either one of those checks fails, then a step **1244** will keep the electronic key disabled, and the logic flow will return to other CCC routines at a step **1246**.

If the correct owner and a valid electronic key are authenticated by the clearinghouse computer at step **1240**, then a step **1242** will re-enable this electronic key. This could be done in many different ways, but as a minimum the central clearinghouse computer will have to send some type of data message that will either be manually entered into the electronic key, via its keyboard or keypad, or the electronic key will be allowed to communicate directly with the clearinghouse computer over the Internet, for example. In the latter situation, the electronic key could receive a data message directly from the clearinghouse computer, and once it has been reset or "re-enabled," then the logic flow can return to other CCC routines at step **1246**.

It obviously is an inconvenience for the user to have to go through the resetting or re-enabling of his or her electronic key. This creates a distinct incentive to correctly place the dwelling key back into the correct lockbox at the correct time (i.e., at the end of a showing). While this might seem detrimental to the real estate agent in some respect, it is definitely a plus so far as the dwelling owner is concerned, because it will virtually eliminate lost or stolen dwelling keys in short order.

As briefly mentioned above, if instead of a "true" electronic key, a standard SentriLock LLC secure memory card is used to access the lockbox, the same routines can still be implemented for the most part. There would not be any radio communications between the lockbox and the secure memory card, however, there still would be a data exchange when the secure memory card was placed into the lockboxes' card reader receptacle. The card reader on the lockbox would interface to circuits on the secure memory card, as is well known in the art. The variables A, B, C, and D can still be handled by the same routines, and the variables C and D would be memory locations on the secure memory card. The reset disable key routine of FIG. **23** would still take place, although there could be no direct communication over the Internet between the secure memory card and the central clearinghouse computer. Instead, the user would use the typical methodology and hardware for communicating messages between the clearinghouse computer and the secure memory card, like when rejuvenating the secure memory card on a daily basis, for example. This typically would be done by a personal computer or some other device that has a card reader, and also has Internet access to the central clearinghouse computer.

There are several other ways of disabling an electronic key for a lockbox system used in real estate situations. FIGS. **24** and **25** show a second embodiment of the logic that could be utilized to implement the electronic key "lockout" (or "disabled") mode. Referring now to FIG. **24** at a step **1300**, a lockbox access credential check routine begins for the second embodiment. Some of the steps on FIG. **24** are identical to certain steps that were discussed in the flow chart of FIG. **21**. After the routine begins, a decision step **1302** determines whether or not the user and the user's electronic key are properly authorized to access the secure compartment of one of the system's electronic lockboxes. If such user and electronic key combination are not authorized, then access is denied at a step **1304** and the secure compartment door will not be opened. The logic flow then returns to other lockbox routines at a step **1306**.

If the answer was YES in step **1302**, then a decision step **1310** determines if the owner of the electronic key is also the owner of the lockbox. If so, and the user/electronic key were authorized, then access will be allowed to the secure compartment at a step **1314**. After the door has been opened for the secure compartment, the logic flow returns to other lockbox routines at a step **1316**.

If the owner of the electronic key is not also the owner of the lockbox, then the logic flow is directed to a step **1312** where the electronic key sends some information to the lockbox. In this situation the electronic key will send the "last lockbox serial number" and that value will set into the variable named "A". As will be seen in the other flow chart of FIG. **25**, the last lockbox serial number is a multi-digit number that represents the most recent lockbox that shared a communication with this particular electronic key. However, the last lockbox serial number could be equal to zero, under certain circumstances. And that is the next question that is determined in the control logic, at a decision step **1320**.

If A was equal to zero at step **1320**, then the lockbox sends a message to the electronic key at a step **1322**. This message tells the electronic key to set the value of A to "this lockbox serial number." So at the beginning of step **1322** the value of A was equal to zero, and then at the end of that step, the value of A will be equal to the serial number of this lockbox now being accessed.

After the information exchange of step **1322**, a software flag is set to the value one, and this flag is designated "F". This flag means that a showing is in progress at this time, and that information will be important in later steps of this flow chart. A step **1326** now determines whether or not the "lockout mode" has been enabled in this particular realtor system. This logic is more or less equivalent to the logic that was discussed above, in reference to step **1140** on FIG. **21**. If the lockout mode is not enabled for this particular real estate board, then the logic flow will travel to step **1314**, which allows access to the secure compartment. In this portion of the control logic, the access will be permitted regardless of what the value of A might have been when this particular electronic key first approached this particular lockbox.

After it has been determined that the lockout mode is indeed enabled at decision step **1326**, the logic flow is directed to step **1328** in which the lockbox sends a message to the electronic key telling the electronic key to set itself into a disable mode. This is a temporary situation, because it is desirable for the user to be able to use his or her electronic key for showings of other properties, so long as the dwelling key is properly returned to the lockbox of interest, i.e., the lockbox whose serial number was set to the variable A at step **1322**. This type of disablement mode of the electronic key is referred to "Disable Mode #1," on FIG. **25**. There is a different type of disable mode on FIG. **25**, but those modes are controlled by the software in the electronic key, and that circumstance will be discussed in greater detail below.

If A was not equal to zero at step **1320**, then a decision step **1330** determines whether or not A contains the serial number for this present lockbox. If so, then the electronic key will not be disabled at a step **1332**. The logic flow will progress to step **1314**, in which access to the secure compartment will be allowed.

If the value of A at step **1330** is not the same as the present lockbox serial number, then the logic flow is directed to a step **1334**, which determines that the electronic key is to be disabled. After that determination has been arrived at, the logic flow is directed to a decision step **1340** which determines whether or not the lockout mode has been enabled for this realtor system. If not, then the logic flow is directed to the step **1314**, and access to the secure compartment will be allowed.

If the lockout mode has been enabled for this realtor system, then a step **1342** blocks access to the secure compartment, and the lockbox sends a message to the electronic key at a step **1344**, and this message tells the electronic key to go into a disabled mode. After that occurs, the logic flow returns to other lockbox routines at a step **1346**.

Similar to the logic of FIG. **21**, this flow chart of FIG. **24** also has a procedure that checks for proper operation of the lockbox, starting at a step **1350**. A decision step **1352** now determines whether or not the secure compartment door is open. If so, the logic flow quickly returns to other lockbox routines at step **1316**. If not, a decision step **1354** determines whether or not the dwelling key is in the lockbox at this time. If not, then the logic flow quickly returns to other lockbox routines at step **1316**.

If the dwelling key is in the lockbox at step **1354**, then the logic flow is directed to a decision step **1360** that determines whether or not the flag variable F is equal to 1 (i.e., does F=1?). If so, this means that, so far as this lockbox is concerned, a showing has been in progress and probably is about to be completed. For this logic stage to be reached on flow chart of FIG. **24**, a user must have previously accessed the secure compartment of this same lockbox, and have had access to the dwelling key. Moreover, this would only occur if the value of A had been set to zero before the beginning of the control logic that started at decision steps **1302**, **1310**, and **1312**. At step **1360**, if F is not equal to 1, then the logic flow quickly returns to other lockbox routines at step **1316**.

On the other hand, if F is equal to 1 at step **1360**, then a decision step **1362** determines whether or not the variable A is equal to this lockbox's serial number. If not, then the electronic key is to be disabled at a step **1364**. If using the logic of FIG. **25**, discussed below, this will be a somewhat harsher mode of disablement, because for the control logic to have arrived at step **1364**, the electronic key must have been used with a different lockbox before approaching this present lockbox, and moreover, the electronic key was not properly "reset" and, therefore, it still was carrying a lockbox serial number for variable A that is different than the present lockbox's serial number. (At this point in the control logic, the value of A would not be equal to zero, because the flag F would also be zero, and the logic flow would divert at decision step **1360**, and not reach this step **1362**.) This is the mode that "penalizes" the user for forgetting to place the dwelling key back into the secure compartment of the previous lockbox, at an earlier visit to that lockbox. When this occurs, the logic flow is directed to decision step **1340** to determine if the lockout mode has been enabled for this realtor system. If so, then the control logic continues to step **1342** that blocks access to the secure compartment, step **1344** in which the lockbox sends a message to the electronic key telling it to go into a disable mode, and finally returning to other lockbox routines at step **1346**.

On the other hand, if the procedures are properly followed and the showing is "normal" with respect to getting the dwelling key back into the proper lockbox, then the answer at decision step **1362** will be YES. In that event, the logic flow is directed to a step **1370** that sets the flag F to zero, and also sets the variable A to zero. After that occurs, the lockbox sends a message to the electronic key telling the electronic key that it should set itself back into an enabled mode of operation, at a step **1372**. In the next step **1374**, the lockbox sends another message to the electronic key, telling the electronic key to set the value of A equal to zero. This step truly is a critical step in this flow chart; it is where it has been determined by the electronic lockbox that its present encounter with this particular electronic key has been properly concluded, because the secure compartment door is closed and the dwelling key is inside the lockbox secure compartment. In addition, this particular electronic key was not being carried around with a serial number of a different lockbox at the beginning of this showing, and everything is "normal" with respect to how the dwelling key has been handled. Finally, this is the step where the lockbox tells the electronic key to set its variable A to zero, and in that way this electronic key will be prepared for an encounter with a different lockbox. As can be seen from the flow chart, when all this has occurred, the electronic key is also back into its normal mode of operation after being temporarily disabled at step **1364**. The control logic returns to other lockbox routines at step **1316**.

Referring now FIG. **25**, the logic flow of some of the important steps in the electronic key's software for a second embodiment "electronic key credential check" routine, which goes hand in hand with the second embodiment credential check routine of the lockbox, illustrated on FIG. **24**. Starting at a step **1400**, a decision step **1402** determines whether or not the variable C is equal to zero. If so, the logic flow is directed to a step **1410** in which the user approaches a lockbox, and this electronic lockbox and the electronic key trade credentials with one another through digital data messages. This step **1410** is more or less equivalent to steps **1302** and **1310** on FIG. **24**. These steps determine whether or not the user and this particular electronic key are both authorized to access the lockbox now being encountered, and also determine whether or not the electronic key is owned by the same person who owns this present lockbox.

After the credentials have been traded between the electronic devices, and the proper authorizations have been verified to approve this visit to the lockbox by this electronic key, a step **1412** sends a message from the electronic key to the electronic lockbox. This message is the "last lockbox serial number" that was encountered by this electronic key. This "last lockbox" value is set into a variable called "D". When this information reaches the lockbox, it becomes the variable A within the lockbox's processing circuitry, which occurs at step **1312** on FIG. **24**.

The next operational step for the electronic key essentially waits for a reply from the lockbox, which occurs at a step **1414**. The electronic key is expecting to receive the serial number of this present lockbox, and after that information is received, it is placed into a variable known as "C". In the lockbox logic of FIG. **24**, this occurs at step **1322**.

Back at the electronic key's control logic on FIG. **25**, a step **1416** stores the value of C into the electronic key's memory circuit. After that occurs, a step **1420** expects another message from the lockbox, telling the electronic key that a showing is now occurring. A flag having the variable name "E" is now set to the value 1. This message from the lockbox occurs at step **1324** on FIG. **24**.

Once the flag E has been set to 1, a step **1422** will prepare to disable the operation of this electronic key. First a message will be displayed on the electronic key's monitor screen, a message such as "SHOWING IN PROGRESS." After that has occurred, the electronic key will enter a Disable Mode #1, which occurs at a step **1424**. After that occurs, the logic flow returns to the electronic key's other functions, but these will only be limited functions, as noted at a step **1426** on FIG. **25**.

This first Disable Mode #1 is meant to be only a temporary mode, and it is up to the system designer to decide exactly which functions will be truly disabled in the electronic key. At the same time, it will be understood that Disable Mode #1 should have some harshness to it, and that means that the exchange of data wirelessly between the electronic key and lockboxes will be restricted or completely discontinued during Disable Mode #1. Other functions of the electronic key can also be curtailed, if desired, including the ability to access certain settings that correspond to various options or main functions of how the electronic key can be used with a lockbox system. If something unusual happens, and this electronic key never gets re-enabled, then the user needs to have the ability to have this disabled electronic key communicate (either directly or indirectly) with the central clearinghouse computer, so that the key can be re-enabled, along the lines of the logic flow presented in FIG. **23**.

As can be seen from the above, in this second embodiment the electronic key actually is disabled as soon as the lockbox is accessed so the dwelling key can be physically made available to the user. In the first embodiment discussed above in reference to FIG. **22**, the actual disablement did not occur until the second encounter between the electronic key and a particular lockbox for the same dwelling site. Both embodiments prevent the electronic key from accessing a different lockbox altogether, its just a matter of exactly how and when the electronic key will be disabled that makes up the significant differences between the first and second embodiments.

Back at decision step **1402**, if the value of C was not equal to zero, then this would indicate that a showing has started and probably is now about to end. A step **1430** is reached when the user approaches the lockbox and the electronic key will expect to receive a particular message from that lockbox. This control logic will be reached because the value of C is no longer equal to zero (it was set to the present lockbox's serial number at step **1414**); also the "showing occurring now" flag E has been set to 1. In these circumstances the re-enable message is expected by the electronic key, and it essentially waits for that to occur at a decision step **1432**. If the message has not been received at this point in time, then the logic flow is directed to the "return to only limited functions," at step **1426**.

On the other hand, if the re-enable message is received at the electronic key, then the logic flow from step **1432** will arrive a decision step **1434** to determine whether or not the flag E is equal to 1. If not, then the logic flow is directed back to step **1426**, and the electronic key is limited (presently in Disable Mode #1). This is an anomalous situation that usually would not occur, but if it does the electronic key will be maintained in the Disable Mode #1 state.

If the value of E is equal to 1 at step **1434**, then the electronic key will now return to its full functioning mode of operation at a step **1440**. This might be a temporary situation, because additional logic still must be analyzed. At a step **1442**, the electronic key receives the serial number of this present lockbox, and will set that value into a variable known as "D". A decision step **1444** will now compare the values of C and D, and if they do not match, a step **1450** will disable the electronic key in a more harsh mode. On the flow chart of FIG. **25**, this is called "Disable Mode #2," and in this mode of disablement, a reset will be required from the clearinghouse computer before the electronic key will be allowed to operate again.

On the other hand, if everything has been proceeding under normal circumstances, the value of C will match the value of D at step **1444**, then a decision step **1445** indirectly determines if the proper dwelling key has been placed back into the lockbox.

Decision step **1445** is part of the control logic for the electronic key, and its processing circuit really cannot directly determine whether or not the dwelling key is back in the lockbox's secure compartment, or whether the door of the lockbox's secure compartment is closed. But it can infer that information from a data message that the lockbox sends at step **1374** in the flow chart of FIG. **24**. In step **1370**, the lockbox tells the electronic key to set variable A to zero; that logic step only occurs if the "proper operation check" logic in steps **1350**, **1352**, and **1354** have determined that the dwelling key is back into a secure compartment, behind a closed door, of the lockbox. This message that A=0 is the result of this "proper operation" of the lockbox by its current user, and that information will eventually result in the variable C at the electronic key being reset to zero. But first, the lockbox's message must be received and analyzed by the electronic key, which occurs at decision step **1445**.

If the answer is NO at decision step **1445**, then the logic flow is directed to the "Return to Other EK Routines" step **1448**, and the electronic key will keep operating (i.e., it will not be disabled), but its variables C and D will not be reset to zero. However, if the answer is YES at decision step **1445**, then the logic flow is directed to a step **1446** allows this electronic key to continue functioning for all normal modes of operation. In step **1446**, the values for variables C and D are both set to zero in the electronic key, thereby readying the electronic key for the next lockbox encounter. The logic flow will now return to other electronic key routines at a step **1448**.

If the electronic key has been placed into the harsher Disable Mode #2, then the routine illustrated on FIG. **23** must be performed so that the electronic key can be re-enabled. Of course, part of the reset routine is to confirm the credentials of both the user and the electronic key to the central clearinghouse computer. If something is amiss along those lines, then the central clearinghouse computer will not send the required message that will re-enable the electronic key.

The flow charts on FIGS. **21** and **24** show two different embodiments of "locking out" or "disabling" an electronic key, in which the major control decisions are made by the electronic lockbox. The control logic illustrated in FIG. **22** shows an alternative scheme by which the electronic key itself will make the decision as to whether or not it should be locked out or disabled. The FIG. **22** software more or less runs hand in hand with the lockbox flow chart of FIG. **21**. The flow chart of FIG. **25** shows the control logic for an electronic key running in a system according to the second embodiment. In this situation, the electronic key does not, by itself, make the decision as to whether or not it should be disabled. Instead, that decision is made by the electronic lockbox, at various stages of the control logic. On the other hand, it could be said that the control logic of FIG. **25** is a guide for a third embodiment, in which the electronic key makes its own determination with respect to whether or not it should be disabled. Of course, certain information must be sent to the electronic key from the lockbox, or it will not be able to make the disablement mode decisions, as per the flow chart of FIG. **25**. Naturally, other control logic schemes could be arrived at, without departing from the principles of the technology disclosed herein.

It will be understood that the logical operations described in relation to the flow charts of FIGS. **4**-**8** and **21**-**25** can be implemented using sequential logic (such as by using microprocessor technology), or using a logic state machine, or perhaps by discrete logic; it even could be implemented using parallel processors. One preferred embodiment may use a microprocessor or microcontroller (e.g., the processor **16**) to execute software instructions that are stored in memory cells within an ASIC. In fact, an entire microprocessor (or microcontroller, for that matter), along with RAM and executable ROM, may be contained within a single ASIC, in one mode of the technology disclosed herein. Of course, other types of circuitry could be used to implement these logical operations depicted in the drawings without departing from the principles of the technology disclosed herein. In any event, some type of processing circuit will be provided, whether it is based on a microprocessor, a logic state machine, by using discrete logic elements to accomplish these tasks, or perhaps by a type of computation device not yet invented; moreover, some type of memory circuit will be provided, whether it is based on typical RAM chips, EEROM chips (including Flash memory), by using discrete logic elements to store data and other operating information, or perhaps by a type of memory device not yet invented.

It will also be understood that the precise logical operations depicted in the flow charts of FIGS. **4**-**8** and **21**-**25**, and discussed above, could be somewhat modified to perform similar, although not exact, functions without departing from the principles of the technology disclosed herein. The exact nature of some of the decision steps and other commands in these flow charts are directed toward specific future models of lockbox systems (those involving lockboxes sold by SentriLock, LLC, for example) and certainly similar, but somewhat different, steps would be taken for use with other models or brands of lockbox systems in many instances, with the overall inventive results being the same.

As used herein, the term “proximal” can have a meaning of closely positioning one physical object with a second physical object, such that the two objects are perhaps adjacent to one another, although it is not necessarily required that there be no third object positioned therebetween. In the technology disclosed herein, there may be instances in which a “male locating structure” is to be positioned “proximal” to a “female locating structure.” In general, this could mean that the two male and female structures are to be physically abutting one another, or this could mean that they are “mated” to one another by way of a particular size and shape that essentially keeps one structure oriented in a predetermined direction and at an X-Y (e.g., horizontal and vertical) position with respect to one another, regardless as to whether the two male and female structures actually touch one another along a continuous surface. Or, two structures of any size and shape (whether male, female, or otherwise in shape) may be located somewhat near one another, regardless if they physically abut one another or not; such a relationship could still be termed “proximal.” Moreover, the term “proximal” can also have a meaning that relates strictly to a single object, in which the single object may have two ends, and the “distal end” is the end that is positioned somewhat farther away from a subject point (or area) of reference, and the “proximal end” is the other end, which would be positioned somewhat closer to that same subject point (or area) of reference.

Some additional information about “basic” lockbox embodiments, including advanced features, are more fully described in earlier patent documents by the same inventor, and assigned to SentriLock, Inc. or SentriLock LLC, including: U.S. Pat. No. 7,009,489, issued Mar. 7, 2006, for ELECTRONIC LOCK SYSTEM AND METHOD FOR ITS USE; U.S. Pat. No. 6,989,732, issued Jan. 24, 2006, for ELECTRONIC LOCK SYSTEM AND METHOD FOR ITS USE WITH CARD ONLY MODE; U.S. Pat. No. 7,086,258, issued Aug. 8, 2006, for ELECTRONIC LOCK BOX WITH SINGLE LINEAR ACTUATOR OPERATING TWO DIFFERENT LATCHING MECHANISMS; U.S. Pat. No. 7,420,456, issued Sep. 2, 2008, for ELECTRONIC LOCK BOX WITH MULTIPLE MODES AND SECURITY STATES; U.S. Pat. No. 7,193,503, issued Mar. 20, 2007, for ELECTRONIC LOCK SYSTEM AND METHOD FOR ITS USE WITH A SECURE MEMORY CARD; U.S. Pat. No. 7,999,656, issued on Aug. 16, 2011, for ELECTRONIC LOCK BOX WITH KEY PRESENCE SENSING; U.S. Pat. No. 7,734,068, issued Jun. 8, 2010, for ELECTRONIC LOCK BOX USING A BIOMETRIC IDENTIFICATION DEVICE; U.S. patent application Ser. No. 11/954,695, filed on Dec. 12, 2007 (Publication No. US 2008/0246587), for ELECTRONIC LOCK BOX WITH TRANSPONDER BASED COMMUNICATIONS; U.S. Pat. No. 8,164,419, issued on Apr. 24, 2012, for ELECTRONIC LOCK BOX WITH TIME-RELATED DATA ENCRYPTION BASED ON USER-SELECTED PIN; U.S. Pat. No. 8,151,608, issued on Apr. 10, 2012, for ELECTRONIC LOCK BOX WITH MECHANISM IMMOBILIZER FEATURES; U.S. patent application Ser. No. 12/756,741, filed on Apr. 8, 2010 (Publication No. US 2011/0251876), for ELECTRONIC LOCK BOX SYSTEM WITH INCENTIVIZED FEEDBACK; and U.S. patent application Ser. No. 12/883,628, filed on Sep. 16, 2010 (Publication No. US 2012/0068817), for ELECTRONIC LOCK BOX PROXIMITY ACCESS CONTROL. These patent documents are incorporated by reference herein, in their entirety.

All documents cited in the Background and in the Detailed Description are, in relevant part, incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the technology disclosed herein.

The foregoing description of a preferred embodiment has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the technology disclosed herein to the precise form disclosed, and the technology disclosed herein may be further modified within the spirit and scope of this disclosure. Any examples described or illustrated herein are intended as non-limiting examples, and many modifications or variations of the examples, or of the preferred embodiment(s), are possible in light of the above teachings, without departing from the spirit and scope of the technology disclosed herein. The embodiment(s) was chosen and described in order to illustrate the principles of the technology disclosed herein and its practical application to thereby enable one of ordinary skill in the art to utilize the technology disclosed herein in various embodiments and with various modifications as are suited to particular uses contemplated. This application is therefore intended to cover any variations, uses, or adaptations of the technology disclosed herein using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this technology disclosed herein pertains and which fall within the limits of the appended claims.

What is claimed is:

1. A method for operating an electronic lockbox system, said method comprising:

(a) providing a plurality of electronic lockboxes and a plurality of electronic keys;

(b) of said plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of said first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within said first secure compartment;

(c) of said plurality of electronic keys, providing a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device; and

(d) initiating a data exchange between said first electronic lockbox and said first electronic key, using said first and second short range wireless communications devices;

(i) at said first electronic lockbox, receiving a first data message from said first electronic key, said first data message containing at least one of:

(A) identity information for said first electronic key, and

(B) personal ID data regarding a specific human user;

(ii) if a user is attempting to access said first secure compartment, then allowing access if said first electronic key's identity information and said specific user's personal ID data are authorized to access the first secure compartment, so that said predetermined dwelling key security apparatus can be removed from the first secure compartment; and

(iii) temporarily disabling effective operation of said first electronic key from accessing any other of said plurality of electronic lockboxes except said first electronic lockbox, until said predetermined dwelling key security apparatus is returned to said first secure compartment, as determined by said first sensor.

2. The method of claim **1**, wherein said first electronic key comprises one of: (a) a smart phone; and (b) a portable computer with a wireless communication circuit.

3. An electronic lockbox system, said system comprising:

(a) a plurality of electronic lockboxes and a plurality of electronic keys;

(b) of said plurality of electronic lockboxes, a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of said first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within said first secure compartment; and

(c) of said plurality of electronic keys, a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device;

wherein said first and second processing circuits are programmed with computer code to perform functions of:

(d) initiating a data exchange between said first electronic lockbox and said first electronic key, using said first and second short range wireless communications devices;

(i) at said first electronic lockbox, receiving a first data message from said first electronic key, said first data message containing at least one of:

(A) identity information for said first electronic key, and

(B) personal ID data regarding a specific human user;

(ii) if a user is attempting to access said first secure compartment, then allowing access if said first electronic key's identity information and said specific user's personal ID data are authorized to access the first secure compartment, so that said predetermined dwelling key security apparatus can be removed from the first secure compartment; and

(iii) temporarily disabling effective operation of said first electronic key from accessing any other of said plurality of electronic lockboxes except said first electronic lockbox, until said predetermined dwelling key security apparatus is returned to said first secure compartment, as determined by said first sensor.

4. The system of claim **3**, wherein said first electronic key comprises one of: (a) a smart phone; and (b) a portable computer with a wireless communication circuit.

5. A method for operating an electronic lockbox system, said method comprising:

(a) providing a plurality of electronic lockboxes and a plurality of secure memory cards;

(b) of said plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a data entry device, a first card reader circuit, a first secure compartment having a first movable opening element that is under the control of said first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within said first secure compartment;

(c) of said plurality of secure memory cards, providing a portable first secure memory card having a second memory circuit, and a card reader interface;

(d) initiating a data exchange between said first electronic lockbox and said first secure memory card, using said card reader circuit and said card reader interface;

(i) at said first electronic lockbox, retrieving first data from said first secure memory card, said data containing at least one of:

(A) identity information for said first electronic key, and

(B) personal ID data regarding a specific human user;

(ii) if a user is attempting to access said first secure compartment, then allowing access if said first secure memory card's identity information and said specific user's personal ID data are authorized to access the first secure compartment, so that said predetermined dwelling key security apparatus can be removed from the first secure compartment; and

(iii) temporarily disabling effective operation of said first secure memory card from accessing any other of said plurality of electronic lockboxes except said first electronic lockbox, until said predetermined dwelling key security apparatus is returned to said first secure compartment, as determined by said sensor.

6. The method of claim **5**, wherein said first electronic key comprises one of: (a) a smart phone; and (b) a portable computer with a wireless communication circuit.

7. A method for operating an electronic lockbox system, said method comprising:

(a) providing a plurality of electronic lockboxes and a plurality of electronic keys;

(b) of said plurality of electronic lockboxes, providing a first electronic lockbox having: a first processing circuit, a first memory circuit, a first short range wireless communications device, a first secure compartment having a first movable opening element that is under the control of said first processing circuit, and a first sensor for detecting whether a predetermined dwelling key security apparatus is present within said first secure compartment;

(c) of said plurality of electronic keys, providing a portable first electronic key having a second processing circuit, a second memory circuit, a data entry device, a display, and a second short range wireless communications device; and

(d) initiating a data exchange between said first electronic lockbox and said first electronic key, using said first and second short range wireless communications devices;

(i) at said first electronic lockbox, receiving a first data message from said first electronic key, said first data message containing at least one of:

(A) identity information for said first electronic key, and

(B) personal ID data regarding a specific human user;

(ii) if a user is attempting to access said first secure compartment, then allowing access if said first electronic key's identity information and said specific user's personal ID data are authorized to access the first secure compartment, so that said predetermined dwelling key security apparatus can be removed from the first secure compartment to begin a showing;

(iii) at said first electronic key, receiving a second data message from said first electronic lockbox that contains first identification information about said first electronic lockbox, and storing said first identification information in said second memory circuit as "opening identification data;"

(iv) temporarily disabling effective operation of said first electronic key from accessing any other of said plurality of electronic lockboxes except said first electronic lockbox;

(v) at said first electronic lockbox, determining, by use of said first sensor, if said predetermined dwelling key security apparatus is returned to said first secure compartment to end a showing, and if so, then:

(vi) at said first electronic key, receiving a third data message from one of said plurality of electronic lockboxes, said third data message containing second identification information about the one of said plurality of electronic lockboxes, and storing said second identification information in said second memory circuit as "closing identification data;" and

(vii) at said first electronic key, comparing said opening identification data and said closing identification data, and:

(A) if said opening and closing identification data match, then automatically re-enabling said first electronic key to function in all normal ways, including for accessing the other of said plurality of electronic lockboxes; and

(B) if said opening and closing identification data do not match, then automatically leaving said first electronic key disabled.

8. The method of claim **7**, wherein said first electronic key comprises one of: (a) a smart phone; and (b) a portable computer with a wireless communication circuit.

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